

**"VARIATION IN LEAF NUTRIENT STATUS, YIELD
AND QUALITY AS AFFECTED BY VARYING LEVELS
OF N, P AND K, METHOD AND TIME OF
APPLICATION OF FERTILIZERS AND SAMPLING
TECHNIQUE ON KINNOW"**

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TECHNOLOGY
INDIAN AGRICULTURAL RESEARCH INSTITUTE
NEW DELHI – 110 012**

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OF N, P AND K, METHOD AND TIME OF
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By

S. MANIVANNAN

A Thesis

*Submitted to the Post-Graduate School,
Indian Agricultural Research Institute, New Delhi,
In partial fulfilment of the requirements for the degree of*

**DOCTOR OF PHILOSOPHY
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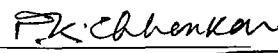
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CERTIFICATE

This is to certify that the thesis entitled "**Variation in leaf nutrient status, yield and quality as affected by varying levels of N, P and K, method and time of application of fertilizers and sampling technique on kinnow**", submitted in partial fulfilment of the requirements for the award of the Degree of **Doctor of Philosophy in Horticulture**, to the Faculty of the Post Graduate School, New Delhi, embodies the results of *bona fide* research work carried out by **Mr. S. Manivannan**, under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma. The assistance and help received during the course of investigation has been duly acknowledged by him.

Place : *New Delhi*
Date : *10/01/2002*

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Abbreviations

N	-	Nitrogen
P	-	Phosphorus
K	-	Potassium
Ca	-	Calcium
Mg	-	Magnesium
S	-	Sulphur
Mn	-	Manganese
Zn	-	Zinc
Cu	-	Copper
Fe	-	Iron
B	-	Boron
Mo	-	Molybdenum
KCl	-	Potassium chloride
EC	-	Electrical conductivity
OC	-	Organic carbon
HCl	-	Hydrochloric acid
HNO ₃	-	Nitric acid
HClO ₄	-	Perchloric oxide
NO ₂	-	Nitrous oxide

1. INTRODUCTION

Citrus is one of the world's leading fruit crops. Among the citrus group, Kinnow mandarin occupies predominant place in the citrus industry of India with an area of 33,638 ha and production of 3,20,745 MT of fruits (NHB, 1999). Most of the Kinnow growing areas are confined to north-west India. Kinnow is valued for its juice, dessert and medicinal properties. Kinnow production has been constantly increasing both as a result of increasing area and productivity. However, in the new world order, not only production and productivity are important but also the quality and sustainability. Though this is a positive shift, there is a constant need to increase the production to satisfy the needs of ever increasing population. Since, the availability of land is limited, this can only be possible by increasing productivity.

Kinnow being a nutrient loving plant, its productivity largely depends upon adequate fertilizer application. However, the injudicious application of fertilizer results in polluting lithosphere, hydrosphere and biosphere besides adding to the cost of production while adversely affecting fruit quality. So it becomes imperative to use optimum dose of fertilizers to produce maximum possible yield while maintaining quality and safeguarding environment. This is possible only by following optimum doses of fertilizers. To achieve these objectives several approaches have been followed. As a consequence, leaf

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nutrient analysis has been rated to be superior technique for assessing nutrient requirements of perennial tree crops. This is based on the assumption that, within certain limits, there is a positive relationship between doses of nutrients supplied, leaf content and yield.

One of the first approach followed was the survey of orchards which gave correlation between the yield level with leaf nutrient content. Though the survey work gave some kind of information, it didn't give accurate prediction on yield as well as quality. It led the researchers to lay out fertilizer trials with specific elements and analyse leaf nutrient content and establish its correlation with yield.

The nutrient levels have been reported to be affected by different factors like plant tissue and its age, position on shoot, flush, type of shoot, leaf size, leaf health, root stock, crop load, tree variation, plant size and sample size and are often cultivar and region specific. Apart from these factors some of the soil, atmospheric and sample handling factors also affect the leaf nutrient content.

Keeping the above information in view it was proposed to take up the present study entitled "Variation in leaf nutrient status, yield and quality as affected by varying levels of N, P and K, method and time of application of fertilizers and sampling technique on Kinnow with the following objectives:

1. To study the effect of sampling techniques on leaf nutrient status of Kinnow.

2. To study the effect of graded doses of N, P and K on tissue nutrient status of Kinnow and to optimize the fertilizer dose for sustainable production of Kinnow mandarin.
3. To study the effect of time and method of fertilizer application on tissue nutrient levels in Kinnow.

It is hoped that the information generated in this study will take us closer to fix leaf nutrient standards in Kinnow are treated in North India.

2. REVIEW OF LITERATURE

Nutrient plays an important role in increasing productivity of different crops. Determination of nutrient needs of an orchard, therefore, assumes importance for the fruit growers. The perennial crops as a whole and fruit crops more specifically quite different from seasonal crops in their nutrient requirement due to their size, population, density, rate of growth, rooting pattern etc. In India many fruit crops are grown either without addition of plant nutrients or addition of excessive fertilizers. However, reliable information is needed to decide how much manures and fertilizers should be applied to fruit trees for an economic response. This can be obtained by use of one or more diagnostic methods. Various advantages are attributed to different diagnostic methods but leaf analysis seems to be the best method for identifying the need for application of fertilizers (Bhargava and Chadha, 1988).

Plant analysis, sometimes referred to as leaf analysis, is a technique for correlating the elemental content of the whole plant or one of its parts with either its physical appearance, growth rate, yield or quality of harvested products.

The foliar analysis is based on the assumption that the plant behaviour is related to the concentration of essential minerals in leaf tissue. Therefore, foliar diagnosis as a method of assessing the fertilizer requirements of a given crop is

based on the assumption that, within certain limits, there is a positive relationship between doses of the nutrient supplied, leaf nutrient content and yield.

Earlier, Krantz *et al.*, (1948) outlined the principal objectives for a plant analysis as :

- To aid in determining the nutrient supplying power of the soil.
- To aid in determining the effect of treatment on the nutrient supply in the plant.
- To study relationships between the nutrient status of the plant and crop performance as an aid in predicting fertilizer requirements.
- To help lay foundation for approaching new problems or for surveying unknown regions to determine, where critical plant nutritional experimentation should be conducted.

For the above mentioned objectives, even though plant analysis is said to be an essential tool; soil analysis acts as a subsidiary tool. The combination of soil analysis and plant analysis only can give any meaningful results on nutrient supplying power of the soil and predicting fertilizer requirement of the crop for that particular type of soil.

2.1 Soil Analysis

Soil testing is an important tool in assessing the fertilizer requirement, the reason why Nelson *et al.* (1951) stated that the competent use of soil tests

can make a valuable contribution to the more intelligent management of the soil.

The objectives of soil testing have been stated by Fitts and Nelson (1956) as

1. To group soils into classes for the purpose of suggesting fertilizer.
2. To predict the probability of getting a profitable response to the application of plant nutrients.
3. To help evaluate soil productivity.
4. To determine specific soil conditions that may be improved by addition of soil amendments or cultural practices.

Soil sampling in perennial crop orchard is different from field crops. Since perennial crops are having deep root systems and most of the feeder roots are at different depths, in addition to the surface sampling and sub surface sampling, sampling at deeper layers is also necessary.

As a general rule, the total area represented by one composite sample should not exceed 8 ha (Peck and Melsted, 1973). Studies showed that in Coorg mandarin during winter as much as 75 to 80 % of the root activity was located within a radial distance of 100 cm and nearly 95 % within a depth of 25 cm with 70 % activity on to 10 cm. During early rainy season more than 80 % activity is located in top 10 cm (Hari Prakash Rao, 1996). Edward Raja, (1996) has advised citrus root sampling at a depth of 0-30 cm and at 120 cm lateral

distance from the trunk. Brar *et al.* (1986) have collected soil samples in Kinnow orchard at seven depths viz. 0-15, 15-30, 30-60, 60-90, 90-120, 120-150 and 150-180 cm. However, Mustaffa (1988) has collected soil samples from three different depths viz. 0-20, 20-40 and 40-60 cm in Coorg Mandarin orchard.

Brar *et al.* (1986) stated that healthy Kinnow orchard had the soil characteristics like pH around 8.5, EC 0.14 mmhos/cm organic carbon percentage in top layer around 0.45 and in subsurface around 0.30. In healthy Kinnow orchard pH range has also been reported by Wander in 1952 as between 6.5 to 9.0. Kanwar *et al.* (1965) have reported that the EC of the soil profile of healthy orchard was within 0.5 mmhos/cm.

Brar *et al.* (1986) have also reported that healthy orchards had available phosphorus up to 98.6 kg/ha. Phosphorus in the soil upto 30 cm depth was medium to high while beyond this depth it was low. On available potassium they reported that healthy orchards contained about 187-821 kg/ha available K and it ranged from medium to high in all the profile samples. On micronutrients they reported that healthy orchards contained 0.13 to 2.43 ppm zinc, 0.4 to 1.6 ppm Cu and 2.45 to 5.78 ppm Mn. Zinc and Cu showed decreasing trend with depth and Mn did not show any regular trend with depth.

The pH near to neutral and all the nutrients in available range make any crop grown in that field healthier (Biswas and Mukherjee, 1994). The availability of Fe, Mn, Cu and Zn are reduced by increasing pH (Anjaneyulu, 1996). Mengel and Kirby (1996) reported that the availability of soil nutrients

directly affects the plant nutrient content. B, Zn and Mo deficiencies frequently occur due to their low status in the soil especially in coarse textured soil (Anjaneyulu, 1996). Low organic matter results in Zn deficiency, where as high organic matter results in Cu deficiency. It is further stated extremes of moisture known to induce Fe deficiency.

2.2 Effect of sampling techniques on leaf nutrient status

There are number of factors affecting sampling of leaves in Kinnow. For accurate measure of tissue nutrient content, right physiological part of the plant should be sampled at right time (Bhargava and Raghupathy, 1993). The factors which affect the right physiological stage and right time are time of sampling, position of leaves height of sampling, type of shoot, size of sample and aspect of tree (Kohli *et al.* 1992).

2.2.1 Position of leaf

The position of leaf on the shoot influences the estimation of leaf nutrient content, since the plant part selected should remain relatively uniform in nutritional concentration (Bhargava and Chadha, 1988). Normally in citrus the leaves are collected from first, second and third positions in shoots (Mann and Sindhu, 1983). However, the collection of leaves varies from terminal leaf to base of the shoot. Lallan Ram *et al.* (1997) collected leaves for sampling from middle of the shoot in Nagpur mandarin. In Hissar, Haryana for sweet orange second pair of leaves was selected (Bhutani *et al.*, 1978). In Punjab it was second, third and fourth leaf from terminal (Chitkara and Bhambota, 1971).

The potassium and calcium contents of Coorg mandarin leaves were significantly affected by the zone of leaf sampling on the tree canopy (Manchanda, 1974). Both K and Ca concentrations were highest in leaves sampled from basal zone followed by those from central and top zones of the tree. Koo and Sites (1956) in Valencia orange and Martin Prevel (1966) in Naval and Clementine oranges observed that the leaves taken from the basal and central zones of the trees had significantly higher K content than other zones. Similar trend was observed in Coorg mandarins by Nache Gowda *et al.* (1985) and they opined that this trend might be due to light intensity on the tree. They further stated that N, P, Mg, Zn, Mn, Fe and Cu contents were not affected by zone of leaf sampling.

2.2.2 Effect of aspect of tree

In most of the nutritional trials, a single citrus tree is used as one treatment unit therefore the aspect of the tree did not get much attention among the researchers. In general, the leaves for sampling are collected from all around the tree (Dixit *et al.*, 1979; Mann and Sindhu, 1983 and Singh *et al.*, 1990).

2.2.3 Effect of size of sampling

In India very limited work has been done to standardize the number of leaves required to be collected. However, the number of leaves collected for leaf nutrient analysis varies from five leaves per tree in Mandarin (Sharma and Mahajan, 1990) to hundred leaves per tree in sweet orange Coorg Mandarin

and Kinnow (Iyengar *et al.*, 1982), lemons (Iyengar *et al.*, 1984) and acid lime (Singh, *et al.*, 1990). Singh and Kunwar (1982) collected ten fully matured sweet orange leaves/tree. In Coorg mandarin Mustaffa (1988 and 1989) collected twenty leaves/tree and forty leaves /tree in two different experiments. Kunwar and Singh (1983) collected 50 leaves /tree.

2.2.4 Effect of height of the leaf

Height at which the leaves are collected for sampling also influences the leaf nutrient content. Though it is well recognized, there is very limited work has been done on this aspect. Singh *et al.*, 1990 advocated that the leaves had to be collected at chest height in citrus.

2.2.5 Effect of type of shoot

Citrus leaves are collected from vegetative shoots for nutrient analysis, since reproductive shoots found to translocate food material and nutrients to fruits and flower buds. Leaves of non fruiting terminals are preferred over fruiting terminals (Singh, 1982; Iyengar *et al.*, 1984; Mustaffa, 1989; Sharma and Mahajan, 1990; Singh *et al.*, 1990; Chundawat *et al.* 1991; Sharma *et al.*, 1991; Huchche *et al.*, 1996; Monga *et al.*, 1997; Nijjar and Brar 1997;). However, Channa and Nijjar (1984) have taken leaves from fruiting terminal, since they analysed leaves in relation to granulation of fruits. Munshi *et al.*, 1978 and Manchanda (1974) carried out their experiment on the leaves taken from the fruiting shoots to elucidate the nutritional imbalance, if any, according to the fruits or fruiting rates.

2.2.6 Effect of age of leaf

Age of leaves is an important factor since the accumulation of all the nutrients occurs when leaves become fully matured. In younger leaves accumulation of immobile elements like Ca and B is very slow at the same time in much older leaves the amount of highly mobile elements will be low. So the optimum leaf age has to be identified for leaf analysis.

In general for citrus fruit the optimum leaf age varies from four to eight months. It varies according to fruit species and locations. In Coorg, Mustaffa (1989) selected 4-5 months old leaves for Coorg mandarins. However 4-7 months leaves were found suitable for acid lime (Chandawat *et al.*, 1991). Iyengar *et al* (1982) reported 5 months old leaves were better for mandarins. 5-6 months old leaves were better for most of the citrus species (Kunwar and Singh, 1983). Iyengar *et al.* (1984) also suggested 5-6 months old leaves for lemon cultivar. For Nagpur mandarin Lallam Ram *et al.* (1997) have selected 5-7 months old leaves. For acid lime Huchche *et al.* (1996) reported selection of 5-7 months old leaves. Singh (1982) selected 6 months old leaves for diagnosing nutrients in sweet orange. For Kinnow mandarin Sharma *et al.* (1991) selected 6-8 months old leaves. On the other hand 7 months old leaves were found suitable for Kinnow mandarins (Dixit *et al.*, 1979 and Mann and Sindhu 1983). For sweet orange also seven months old leaves were found suitable by Manchanda, (1974). However, Chitkara and Bhambota (1971) found one year old leaves were optimal for nutrient analysis.

2.2.7 Effect of time of sampling

Any nutrient diagnosis is valid only when the right kind of tissue analysed at right time. Recognising this fact much work has been conducted on this aspect.

In mandarin orange normally spring season leaves are preferred (Dixit *et al.*, 1979, Iyengar *et al.*, 1982; Sharma and Mahajan, 1990; Sharma, *et al.*, 1991). Spring flush leaves during September – November were collected in sweet orange (Bhutani *et al.*, 1978; Monga *et al.*, 1997 and Munshi *et al.*, 1978).

However, some workers to assess the difference in nutrient content as affected by different flushes collected leaves from all three flushes of citrus *viz.*, spring, summer and autumn (Mann and Sindhu, 1983). Among three different flushes of sweet orange the P and N content of leaves did not differ significantly. However, its mean value was higher in autumn flush leaves and the same was true for Mg content also. Leaf P was significantly higher for spring flush and it was found to be at par with summer flush. Whereas reverse was true for Ca content. There was no difference in K content amongst the three flushes (Singh and Kunwar, 1982). Further they stated that most of the citrus trees, in Uttar Pradesh conditions have a heavy flush in spring with most uniform in age. Therefore, leaves from spring flower are easier and uniform in sampling than later flushes.

On the contrary, Singh *et al.* (1990) in acid lime from IIHR, Bangalore reported leaf N,P and K contents were higher in February flush while Ca, Zn and Mn were high in May flush. Further they suggested in tropical climate where soil-moisture stress coupled with high evaporative demand proceeds, the June flush has appeared to be the best as it has more influence on yield.

Nijjar and Brar (1977) in Kinnow and Channa and Nijjar (1984) in sweet orange collected leaves from June onwards at a monthly intervals. In Kinnow fluctuation in foliar N was seasonal and N content in leaves increased in summer and decreased in winter. K also showed a similar trend. Fe content was higher in September and lowest in April. Mn content was higher in August.

2.3 Effect of graded doses of Nitrogen (N) on leaf nutrient status, yield and quality

Nitrogen being a major nutrient element affects the nutrient content of leaves yield and quality of the fruits. Different doses of nitrogen not only influences the leaf N content but also all other essential element status of leaf.

2.3.1 Effect of application of N on primary nutrients

Kohli *et al.* (1992) have reported that all species of citrus requires 300 – 800 g of nitrogen per plant per year to obtain optimum level of leaf nutrient contents in general and leaf nitrogen level in particular. Singh (1998) has stated that Kinnow requires 600-800 g N/Plant/year to give adequate yield and quality fruits. Leaf N concentration increased with amount of N applied in grape fruit

(Kalra and Munshi, 1977) sweet orange (Sarooshi *et al.*, 1991) in Nagpur Mandarin (Lallan Ram *et al.*, 1997).

Koo *et al.* (1974) have reported in Florida for good quality lemon production and for higher yield, the leaf nitrogen content should be of around 2.2 to 2.6 %. Further they stated that this amount of leaf N percentage can be obtained by application of 650 to 935 g of N/tree/yr. Arthur Wallace (1990) has reported that increase in nitrogen application has 6 % response in Valenica orange as a whole which tend to affect other major nutrient content. In his experiment, individual effect of P and K were 5 and 23 % respectively. However, these nutrients when applied together with N the individual responses increased by 2, 2 and 3 per cent for N, P and K respectively. This experiment shows a positive correlation between all the three primary elements *viz.* N, P and K. Similarly Lallan Ram *et al.* (1997) have obtained a positive interaction amongst primary nutrients. In their experiment all the three primary elements in leaves of Nagpur mandarin increased with addition of nitrogen till 600 g/pl/year. However, all the three elements started decreasing when N dose was further increased.

In contrast, Huchche *et al.* (1996) in their experiment stated that increase in N dose upto 800 g/plant/year increased N content in leaves of acid lime. However, P and K content in leaves were decreasing for every incremental N dose upto 600 g N/tree/year. Further increase in N dose beyond 600 g N/tree/N increased the leaf P and K contents. Koo *et al.* (1974) also have stated that increased in N application has a suppressing effect on K. They further

stated that N treatments resulted in lower P content in leaves. On the contrary, Sarooshi *et al.* (1991) reported that the increase in N has not affected the leaf P concentration.

2.3.2 Effect of application of N on secondary nutrients

Bhutani *et al.* (1978) have reported in sweet orange that N and Ca did not have any interaction. However, Bopaiah *et al.* (1982) have found a negative relationship between applied N and leaf Ca. However, Mg content in leaves tend to increase with increase in N (Koo *et al.* 1974). Leaf S has shown a positive interaction with N (Basso *et al.* 1983).

2.3.3 Effect of application of N on micro nutrients

Mann and Sindhu (1983) have found that leaf nitrogen in Kinnow has positive interaction with leaf Zn and Cu contents. However, they found, leaf N content has no effect on Mn and Fe.

Manchanda (1974), however, has shown that none of the micronutrients had any interaction with N content of sweet orange leaves. Similar report has been made by Dixit *et al.* (1979) in Kinnow.

In contrast, applied N has been reported as a possible cause of deficiency in citrus plants (Chapman *et al.*, 1937). Ozanne (1955) observed an increased severity of Zn deficiency in Subterranean clover as the N supply increased regardless of N source but the effect was not due to an increase in growth rate but may be due to pH change. Soltanpour (1969) found that N accentuated uptake of P and Zn in potatoes. Langin *et al.* (1962) observed

generally that fertilizer N enhanced the uptake of Zn despite substantial dilution caused by yield increase from nitrogen.

2.3.4 Effect of application of N on yield and quality

Nitrogen being one of the constituent of chlorophyll increases the photosynthates and in turn it increases the yield and quality. Nitrogen is one of the most important elements which influences growth and yield of citrus trees than any other element Camp *et al.* (1949). Trees receiving higher N have more fruits than the lower doses of N in Foster grape fruit (Kalra and Munshi, 1977). This trend has been confirmed by Radhakrishnan *et al* (1977a) in Kagzi lime where 800 g/plant nitrogen produced maximum yield when compared to lower doses of it. Same trend has been reported by Radhakrishnan *et al* (1977b) in acid lime. Foliar application of N also produced similar increase in yield when concentration and doses were increased (Prasad and Govind, 1977).

In Bearss lemon, fruit production increased with increased rate of N application. Highest fruit production resulted from the high rate of N, although the yield difference between the high (935 g/tree/yr) and medium (650 g/tree/yr) rates were not significant (Koo *et al.*, 1974). Further it was also found that a linear correlation between leaf N and fruit yield, which indicated that leaf N can be used to evaluate yield potential of the tree. Increase in yield with the increasing levels of Nitrogen and reported by Jones *et al.* (1970); Young and Koo (1973) in Persian lime, in Lison lemon and Singh and Mishra (1985) in Pant lemon. For obtaining good yield in Valencia orange the leaf N content should be more than 2.1 percentage (DuPlessis and Koen, 1988). Yield

increase in response to applied N and higher leaf N percentage also been observed in Shanouti variety of citrus by Dasberg (1988).

Though fruit number and fruit yield found to be positively influenced by leaf N, it has a negative effect on fruit size. But the negative effect is less consistent in Valencia orange (DuPlessis and Koen, 1988). Koo *et al.* (1974) too have found similar trend in lemon. However, they observed reduction in acid percentage in juice when the leaf N content increased.

Juice percentage found to be highest in medium range of N application (600 g/tree/yr) than high range (800 g/tree/yr) or low range (200 g/tree/yr) in acid lime. TSS and acidity also have shown a similar trend (Huchche, *et al.*, 1996).

Higher doses of N tend to increase peel percentage but juice content remained unaffected in grape fruits (Kalra and Munshi, 1977).

2.4 Effect of graded doses of Phosphorus (P) on leaf nutrient content, yield and quality

Phosphorus is one of the major element which affects most of the other essential element content in leaves. Since phosphorus interacts highly with micro elements it affects more of fruit quality than of yield (Anjaneyulu, 1996).

2.4.1 Effect of application of P on primary elements

DuPlessis and Koen (1988) observed that increase of P content in leaves as a result of increased application of phosphatic fertilizer is negligible. On the contrary, Sarooshi *et al.* (1991) have reported that the leaf P concentrations

increased with high rates of applied P in sweet orange. Bopaiah *et al.* (1982) have also observed a similar trend in Mandarin orange.

The increased P application did not have any effect on other major nutrients *viz.* N and K in citrus (Mustaffa, 1989, Chundawat *et al.*, 1991 and Lallan Ram *et al.*, 1997).

2.4.2 Effect of application of P on secondary elements

Leaf P content and Ca content did not have any adverse relationship in sweet orange (Bhutani *et al.*, 1978). However, Chundawat *et al.* (1991) have reported that in acid lime Ca and Mg uptake as well as leaf nutrient content increased with increased P application till certain level and then it decreased. Leaf calcium level increased upto certain level with the increase of P level in leaf, later it decreased. However, leaf Mg content increased with additional increase of P in leaf of Coorg Mandarin (Mustaffa, 1988).

2.4.3 Effect of application of P on micro elements

Generally the interaction between Zn and P is called as phosphorous induced Zn deficiency. Higher levels of P fertilization causes Zn deficiency symptoms. The course of P-Zn interaction was suspected to be the formation of an insoluble zinc phosphate in the soil which might be reducing the concentration of Zn on the soil solution to deficiency level (Kalyanasundram and Mehta, 1970). Applied P decreased the Zn concentration, but total uptake of Zn was the same or increased (Brown and Brown, 1968). The cause of this P

induced Zn deficiency may be due to an interference by P with the uptake, translocation or utilization of Zn (Brown and Brown, 1968).

When the rate of plant growth exceeds the rate of uptake of a particular nutrient the concentration of that nutrient in the tissue decreases or is diluted in the plant tissue. The growth rate increases because of applied P but the uptake rate of Zn does not increase fast enough to maintain a sufficient concentration of Zn which leads to a P induced Zn deficiency.

Bingham and Garber (1960) measured significant decrease in the concentration of Cu in sour orange seedlings as the rate of P increased from 90 to 450 ppm. Severe Cu deficiencies were also induced in citrus by applying 180 ppm of P on different types of Californian soils.

Excessive P appears to interfere with movement and metabolic functioning of Fe (Price, 1968). Some experiments indicate that the interaction of Fe and P leading to Fe chlorides which appears to be caused by an internal immobilization of Fe probably due to the formation of Fe and Phosphate (Biddulph, 1953). Watanbe *et al* (1965) observed stunted and extremely Fe – deficient plants when the P level in a nutrient solution was increased from 0.2 to 0.6 mM with Fe EDDHA at 40 μ m.

Stout *et al.* (1951) reported that phosphorus enhanced the absorption and translocation of Mo. Barshad (1951) also suggested that P may stimulate Mo uptake because of the formation of complex phospho-molybdase anion.

2.4.4 Effect of application of P on yield and quality

Phosphorus being essential for root development affects the uptake of all the nutrients and it in turn affects the yield and quality (Salisbury and Ross, 1986). P interacts with all the micro elements. So it affects more of quality of fruits than yield (Anjaneyulu, 1996). Increase of P application produced 5 % of total response in yield and quality of Valencia orange (Arthur Wallace, 1990). P application in medium range induced maximum production of narangins in peels of Marsh grape fruit (Romojaro *et al.*, 1982).

2.5 Effect of graded doses of Potassium (K) on leaf nutrient content, yield and quality

K is the carrier of most of the nutrient element in plants and has marked effect on some of the other elements which in turn affects the quality of the produce. K is considered as the most important element for production of fruits with high quality (Bhargava and Chadha, 1992).

2.5.1 Effect of application of K on primary elements

Arthur Wallace (1990) have shown a negative interaction between applied K and applied N in total response. He reported in Valencia orange that K alone has 23 % response compared to K and N which has only 21 %.

However, by keeping applied N level constant application of varying doses of K did not show any marked difference in leaf N content of lemons (Intrigliolo and Starrantino, 1988). Similar trend has been observed in Nagpur mandarin by Lallan Ram *et al.* (1997). Koo *et al.* (1974) could not find any

kind of interaction between leaf N percentage and applied K in lemon. Huchche *et al.* (1996) also found similar results in acid lime. Mann and Sindhu (1983) in Kinnow could not find any kind of relationship between leaf N percentage and leaf K percentage. In contrast Shankhayan and Bhardwaj (1989) have found a negative interaction between N and K in Kinnow.

Applied K did not have any interaction with P uptake and leaf nutrient content (Mangel and Kirby, 1996).

Applied K positively influenced the leaf K percentage in acid lime (Chundawat *et al.*, 1991). When the dose of applied K was increased, the leaf K percentage also increased in lemon (Koo *et al.* 1974). Similar trend has been observed by Shankhayan and Bhardwaj (1989) in Kinnow. In Shamouti oranges the same trend has been established by Koo (1988). Foliar applied potassium nitrate in Italian and Valencia sweet orange have also shown a positive trend between applied K and leaf K content.

2.5.2 Effect of application of K on secondary nutrients

Limited work done in this aspect especially in fruit crops, makes it difficult to establish any fact. However, to find out any interaction between K and secondary elements review of some of the works can give the preliminary ideas. Applied calcium carbonate has not affected the leaf K level in sweet orange, Guava and Grapes (Bhutani *et al.*, 1978). In the mulching experiment of Mustaffa (1989) there was no established relationship between leaf K and leaf Ca as well as leaf Mg content. But Shankhayan and Bhardwaj (1989) have

established a negative correlation between applied K and leaf Ca and Mg concentrations.

2.5.3 Effect of application of K on leaf micronutrients

Leaf K percentage and leaf Zn percentage showed a positive trend in Kinnow mandarins (Dixit *et al.*, 1979). However, Mann and Sindhu (1983) could not observe any trend between leaf K and leaf Zn in Kinnow. Both Dixit *et al.* (1979) and Mann and Sindhu (1983) could not observe any kind of relation between K and Fe contents in leaves. But they have shown a negative correlation between K and Cu contents. The relation between K and Mn has been shown to be of ambiguous. Increased amount of K decreased leaf B and Mo content (Shankhayan and Bhardwaj, 1989).

2.5.4 Effect of application of K on yield and quality

Increase in leaf K from 0.81 to 1.00 percentage in Valencia orange increased the yield by 23.1 % (Arthur Wallace, 1990). Leaf K content in Shamouti oranges increased at around 42 % when treated with K application, which in turn increased yield by 20-25 % and fruit size by 25-30 % (Koo, 1988). However, Koo *et al.* (1974) did not find any increase in yield of Bearss lemon with the addition of K to trees.

In contrary to these reports, Shankhayan and Bhardwaj (1989) observed that yield on Kinnow plants got reduced when applied K level has been increased. However in second year of their study the trend got reversed. In the

reversed trend too, the yield increase to the increase in applied K was of parabolic nature.

Increasing K applications increased the acid content in fruits (Koo *et al.*, 1974). They further stated that the relationship between K and fruit colour was not consistent. Average fruit weight increased with application of K (Dasberg, 1988). Shankhayan and Bhardwaj (1989) have reported that rind thickness of Kinnow increased with increased application of K. K being a carrier of many nutrients, tend to accumulate more carbohydrate and in the end produce higher TSS (Salisbury and Ross, 1986).

2.6. Effect of time of application of N on leaf nutrient status

Long duration crop like citrus which take up nutrients over a long period, often higher rate of uptake occurs at later stages of growth (Biswas and Mukherjee, 1994). Nitrogen use efficiency always increases with the split application of N by reducing N losses (Sachdev *et al.*, 1990). Judging the number of split doses requires informations on soil characteristics and climate. More splits are needed for sandy soils (Rajendra Prasad, 1999).

Legas and Primo-Millo (1988) have stated that Valencia orange needed high amount of 'N' fertilizers during initiation of spring flush and second flush. During these periods the leaf N content also found to be higher indicating that fertilizer application also should be in these periods. Huchche *et al.* (1996) recommended application of N fertilizers during April, August and November to get maximum yield. A study of the mean inflow rate of nutrients in sweet

orange and Coorg mandarin revealed that it was highest during early and late rainy season indicating the high demand for the nutrient during this period and the possibility of quick absorption if applied at that time (Keshavamurthy, 1996).

2.7. Effect of method of application of N on leaf nutrient status

Placement of nitrogen 5-8 cm below surface has been found to be significantly superior to surface application (Prasad *et al.*, 1971). Vachhani (1952) reported pellet application to be superior to broadcast application. Ammonia volatilization can be almost prevented by deep placement of N fertilizer (Prakash Rao and Bhat, 1984).

Rangpur lime rootstock absorbs nutrients with large number of absorption sites on its roots which indicated the need for specific placement near to absorption sites to get maximum uptake of nutrients. Kinetic studies also revealed that the higher rates of N and P inflow due to a greater number of absorption sites and lower km values (Keshavamurthy, 1996). Bopaiah and Srivastava (1982) have reported that applying fertilizer in 10 cm trench gave higher values of leaf nitrogen than other treatments in Coorg mandarin. For Haryana soil drenching of N is recommended (Singh *et al.*, 1985).

3. MATERIALS AND METHODS

The present study entitled “Variation in leaf nutrient status, yield and quality as affected by varying levels of N, P and K; method and time of application of fertilizers and sampling techniques on Kinnow” was carried out at farmer’s orchard, Farukh Nagar, Gurgaon District, Haryana and Tissue Nutrient Laboratory, National Professor Scheme, Division of Fruits and Horticultural Technology, Indian Agricultural Research Institute, New Delhi, during the period between February 1999 and January 2001.

The materials employed and methods adopted in the course of the investigations are dealt with in this section. The present study was conducted with four main experiments *viz.*,

Experiment No. 1 Effect of sampling techniques on tissue nutrient status of Kinnow.

Experiment No. 2 Effect of varying doses of fertilizers on tissue nutrient status, yield and quality of Kinnow.

Experiment No. 3 Effect of time of application of N fertilizer on tissue nutrient status of Kinnow.

Experiment No. 4 Effect of method of application of N fertilizer on tissue nutrient status of Kinnow.

Among these experiments Experiment No.1 was conducted under four sub experiments *viz.*,

Experiment No. 1(i). Effect of time of sampling on leaf nutrient status of Kinnow.

Experiment No. 1.(ii). Effect of position of leaves on leaf nutrient status of Kinnow.

Experiment No. 1.(iii). Effect of aspect of tree on leaf nutrient status of Kinnow.

Experiment No. 1.(iv). Effect of size of sampling on leaf nutrient status of Kinnow.

Experiment No.2 was conducted under three sub experiments.

Experiment No. 2.(i). Effect of varying doses of N on leaf nutrient status, yield and quality.

Experiment No. 2.(ii). Effect of varying doses of P on leaf nutrient status, yield and quality.

Experiment No. 2.(iii). Effect of varying doses of K on leaf nutrient status, yield and quality.

Initially soil samples were collected from the orchard and analysed for nutrient status from all the experimental blocks.

3.1. Experimental details

3.1.1. Effect of sampling techniques on leaf nutrient status of Kinnow

To assess the accuracy of sampling techniques on tissue nutrient status of Kinnow the following experiments were laid out.

Experiment No. 1.(i) Effect of time of sampling on leaf nutrient status of Kinnow

Plant sample size of 30 leaves/tree were collected at monthly intervals from February 1999 to January 2001, considering each month in a year as treatment with 3 replications. The treatments were

T ₁ – February	T ₇ – August
T ₂ – March	T ₈ – September
T ₃ – April	T ₉ – October
T ₄ – May	T ₁₀ – November
T ₅ – June	T ₁₁ – December
T ₆ – July	T ₁₂ – January

Each tree was applied with the standard fertilizer dose of 600:300:400 g N, P₂O₅ and K₂O/year. Half of N, full P₂O₅ and full K₂O was applied as basal dose during February, ¼th of N was applied during June and another ¼th was applied during August.

Experiment No. 1.(ii) Effect of position of leaves on leaf nutrient status of Kinnow

In this experiment leaf samples were collected from three different positions of a twig viz.,

T₁ – 2nd, 3rd and 4th leaves from non-fruiting terminals of 4-7 months old.

T₂ – middle position of branch from non-fruiting terminals of 4-7 months old twig.

T₃ – leaves form behind the fruits of fruiting terminal.

Each position of sampling was considered as separate treatment with 7 replications. Sample size was 30 leaves/tree. Each tree was applied with the standard fertilizer dose of 600:300:400 g N, P₂O₅ and K₂O/year. Half of N, full P₂O₅ and full K₂O was applied as basal dose during February, ¼th of N was applied during June and another ¼th was applied during August.

Experiment No. 1. (iii) Effect of sample size on leaf nutrient status of Kinnow

In this experiment different sample size of 30, 50, 70 and 90 leaves were collected separately considering each size as a treatment with 5 replications.

The treatments were

T₁ – 30 leaves/tree

T₃ – 70 leaves/tree

T₂ – 50 leaves/tree

T₄ – 90 leaves/tree

Samples were collected from February to October at monthly intervals from terminal positions of 4-7 months old twigs. Each tree was applied with the standard fertilizer dose of 600:300:400 g N, P₂O₅ and K₂O/year. Half of N, full P₂O₅ and full K₂O was applied as basal dose during February, ¼th of N was applied during June and another ¼th was applied during August.

Experiment No. 1.(iv) Effect of aspect of tree on leaf nutrient status of Kinnow

Leaf samples were collected from north, south, east and west directions. Considering each direction as separate treatment. 5 replicational samples were collected from each treatment. The treatments were

T₁ – North

T₂ – South

T₃ – East

T₄ – West

Sample size was 30 leaves/tree. Samples were collected from February to October at monthly intervals from terminal position of 4-7 months old twigs. Each tree was applied with the standard fertilizer dose of 600:300:400 g N, P₂O₅ and K₂O/year. Half of N, full P₂O₅ and full K₂O was applied as basal dose during February, ¼th of N was applied during June and another ¼th was applied during August.

3.1.2. Effect of varying doses of fertilizers on leaf nutrient status, yield and quality of Kinnow

To assess the varying doses of fertilizers on leaf nutrient status, yield and quality of Kinnow the following experiments were laid out.

Experiment No.2.(i) Effect of varying doses of N on leaf nutrient status, yield and quality of Kinnow

The experiment was carried out with the following treatments with 4 replications each.

Treatments	N (g)/tree	P ₂ O ₅ (g)/tree	K ₂ O (g)/tree
T ₁	0	0	0
T ₂	0	300	400
T ₃	150	300	400
T ₄	300	300	400
T ₅	600	300	400
T ₆	750	300	400
T ₇	900	300	400

Leaf sample size was 30 leaves/tree and the samples were collected from February to October at monthly intervals from terminal position of 4-7 months

old non fruiting terminals. Each tree was applied with the standard fertilizer dose of 600:300:400 g N, P₂O₅ and K₂O/year. Half of N, full P₂O₅ and full K₂O was applied as basal dose during February, ¼th of N was applied during June and another ¼th was applied during August.

Experiment No.2.(ii) Effect of varying doses of P on leaf nutrient status, yield and quality of Kinnow

The experiment was carried out with following treatments with 4 replications.

Treatments	N (g)/tree	P ₂ O ₅ (g)/tree	K ₂ O (g)/tree
T ₁	0	0	0
T ₂	600	0	400
T ₃	600	150	400
T ₄	600	300	400
T ₅	600	600	400

Leaf sample size was 30 leaves/tree and the samples were collected from February to October at monthly intervals from terminal position of 4-7 months old non fruiting terminals. Each tree was applied with the standard fertilizer dose of 600:300:400 g N, P₂O₅ and K₂O/year. Half of N, full P₂O₅ and full K₂O was applied as basal dose during February, ¼th of N was applied during June and another ¼th was applied during August.

Experiment No.2. (iii) Effect of varying doses of K on leaf nutrient status, yield and quality

Treatments	N (g)/tree	P ₂ O ₅ (g)/tree	K ₂ O (g)/tree
T ₁	0	0	0
T ₂	600	300	0
T ₃	600	300	200
T ₄	600	300	400
T ₅	600	300	800

Leaf sample size was 30 leaves/tree and the samples were collected from February to October at monthly intervals. From terminal position of non fruiting terminals of 4-7 months old. Each tree was applied with the standard fertilizer dose of 600:300:400 g N, P₂O₅ and K₂O/year. Half of N, full P₂O₅ and full K₂O was applied as basal dose during February, ¼th of N was applied during June and another ¼th was applied during August.

3.1.3. Effect of time of application of N on leaf nutrient status of Kinnow

To assess the proper time of application the following treatments were carried out. The N fertilizer was applied in 4 different time intervals. Each treatment with 5 replications.

T₁ – Bimonthly – Feb., Apr., June, Aug., Oct. and Dec.

T₂ – Trimonthly – Feb., May, Aug. and Nov.

T₃ – Quarterly – Feb., June and Oct.

T₄ – Half yearly – Feb. and July.

P and K standard doses i.e. 300 g and 400 g respectively were applied fully during February as basal application. The standard dose of N i.e. 600 g/tree/year was divided into six equal parts and applied in each application of T₁. The dose was divided into four equal parts and applied in each application of T₂. In T₃ the N dose was divided into two equal parts in that one part was applied as basal during February and another part was again divided into two equal parts and applied in June and October. In T₄ total N dose was divided into two equal part and applied during February and July.

3.1.4. Effect of method of application of N on leaf nutrient status of Kinnow

To assess the proper method of application the following treatments were carried out with 5 replications.

T₁ – Broadcast

T₂ – Ring method

T₃ – X method

T₄ – Pocket method

In T₁, fertilizer has been simply applied on surface. In T₂, at drip circle 15 cm trench has been made around the tree and fertilizer has been applied in it. In T₃, a crisscross trench of 15 cm depth has been made under the canopy of the tree and fertilizer has been applied. In T₄, 15cm depth holes have been made on the four directions at drip circle and fertilizer has been applied in it.

Leaf sample size was 30 leaves/tree and the samples were collected from February to October at monthly intervals. From terminal position of non fruiting terminals of 4-7 months old, each tree was applied with the standard fertilizer dose of 600:300:400 g N, P₂O₅ and K₂O/year. Half of N, full P₂O₅ and full K₂O was applied as basal dose during February, ¼th of N was applied during June and another ¼th was applied during August.

3.1.5. Statistical design

For all the experiments standard Randomized Block Design (RBD) was followed.

3.2 Soil analysis

3.2.1. Soil sampling

Soil samples for nutrient analysis were collected randomly from three different depths viz., 0-15, 15-30 and 30-45cm with seven replications using khurpi and screw type auger. For taking samples at surface level, i.e., from 0-15cm khurpi was used. 'V' shape cut was made in the surface layer and a uniform 1.5 cm thick slice was taken out. For subsurface and deeper layers

screw auger was used. The collected soil samples were thoroughly mixed and bulk was reduced by quartering so that about 500g of composite samples is retained. The samples of three different depths were kept separately in a cloth bag with suitable description and identification marks.

3.2.2. Preparation of soil samples

The collected samples were dried in air under shade. The dried samples were crushed gently with wooden pestle and mortar and sieved through a 2mm stainless steel sieve. The materials larger than 2mm sieve were discarded. The materials passed through the sieve were kept in a plastic container with proper labels.

3.2.3. Soil nutrient analysis

The prepared soil samples were taken for nutrient and other analysis.

3.2.3. a. Determination of soil pH

Soil pH was determined by using pH meter. 20g of soil samples were weighed and 40 ml of distilled water was added. The contents were stirred with glass rod and then allowed to stand for an hour. pH meter was calibrated using buffer solutions and then the pH of soil solutions were measured.

3.2.3. b. Determination of soil Electrical Conductivity (EC)

EC was determined using EC meter. 20g of soil samples were weighted and 40 ml distilled water was added to each of the samples. The contents were

shaked for an hour and kept for getting clean solution. The EC meter was calibrated with 0.01M and 0.1M KCl solutions and after calibration soil solutions were measured for EC.

3.2.3.c. Determination of nutrients in soil

The following nutrients are determined by methods mentioned below:

- | | | |
|--------------------------------------------|-------------------------------------|-------------------------------|
| 1. Organic carbon | Dichloric acid wet oxidation method | - Walkley & Black 1934 |
| 2. Available N | Alkaline permanagometry | - Subbaiah & Asija, 1956 |
| 3. Available P ₂ O ₅ | Ascorbic acid Yellow colour method | - Olsen <i>et al.</i> , 1954 |
| 4. Exchangable K | Flame photometry | -Schollenberger & Simon, 1945 |
| 5. Exchangeable Ca and Mg | Atomic Absorption Spectrophotometer | -Soltanpur & Schwab 1977 |
| 6. Available S | Turbidometry | -Massoumi and Corn field 1963 |
| 7. Micronutrients (Mn, Zn, Cu, Fe) | Atomic Absorption Spectrophotometer | - Soltanpur & Schwab, 1977 |

3.3. Plant analysis

3.3.1. Plant sampling

Kinnow leaf samples were collected from an orchard located near to Farukh Nagar, Gurgaon district, Haryana. The Kinnow plants were eight years old, grown in 6 x 6 M spacing and grafted on Karna Khatta (*Citrus karna*) root stock.

The leaves were collected from terminal position i.e. from 2nd, 3rd and 4th leaf position of non-fruiting terminals, except in the experiment of effect of position of leaves on leaf nutrient status. In this experiment leaves were collected from three different positions namely terminal position of non-fruiting terminal, middle position of non-fruiting terminal and behind the fruits of fruiting terminal. The number of leaves collected were 30, except in the experiment of size of sampling on leaf nutrient status. In this experiment, leaf number was kept at four different levels viz., 30, 50, 70 and 90 leaves. The leaf samples were collected from February till the harvest of fruits (October), at monthly intervals except in the experiment of time of sampling, where samples were collected from February to January at monthly intervals. Moreover, the plant samples were collected all around the tree except in the experiment of aspect of tree on leaf nutrient status. In this experiment, leaf samples were collected from east, west, north and south directions. Collected samples were kept in properly labelled polythene bags and brought to laboratory within 24 hours.

3.3.2. Plant sample preparation

Fresh leaves were decontaminated from dust and others by washing them in a liquid detergent solution having concentration of 2ml/lit. followed by washing them in N/10 HCl solution. After washing them in acid solution, the leaves were rinsed with distilled water 2 to 3 times. The extra moisture was wiped out and the samples were placed in new paper bag and dried in an oven at 70°C with proper labels. The plant samples were dried for 24 hours to 36 hours. After drying, the leaves were milled and sieved through 1mm sieve. The ground samples were stored in an air tight plastic vials with clear labels.

3.3.3. Digestion of plant samples

The diacid digestion was used for the determination of leaf P, K, Ca, Mg, S, Mn, Zn, Cu and Fe. In this digestion 2g of ground plant material was taken in 100ml volumetric flasks. To this, 10ml of diacid mixture (9:4 mixture of HNO₃: HClO₄) was added and the contents of the flasks were mixed by swirling. These flasks were placed in low heat hot plate in a digestion chamber. Then, the flasks were heated at higher temperature until the production of red NO₂ fumes ceases. The contents were further evaporated until the volume was reduced to about 2 to 3ml. The completion of digestion was confirmed when the liquid became colourless.

After cooling the flasks 20ml of distilled water was added to each flask. The solution was filtered through Whatman No.1 filter paper. Volume was made upto 100 ml with distilled water in a 100 ml volumetric flask.

3.3.4. Estimation of nutrients

The estimations of nutrients were carried out by the following methods.

1. Total Nitrogen	- Auto analyser	-Isaac & Johnson, 1976
2. Phosphorus	-Vanadate phospho molybdate method	- Jackson, 1958
3. Potassium	- Flame photometry	-Chapman & Pratt, 1961
4. Calcium and Magnesium	- Atomic absorption spectrophotometry	- Jones, Jr., 1985
5. Sulphur	-Turbidometriy	Beaton <i>et al.</i> , 1968
6. Manganese, Zinc, Copper and Iron	- Atomic absorption spectrophotometry	- Jones, Jr. 1985

3.4. Yield and quality analysis

3.4.1. Yield parameters

Yield was calculated for each treatment. The fruits of each treatment's replicational unit were harvested separately. Number of fruits/tree was counted. Individual fruit weight was calculated by selecting randomly five fruits/replication of a treatment and average was taken.

3.4.2. Quality analysis

The harvested fruits, at the rate of two per replication of a treatment were brought to laboratory and analysed for Juice percentage, TSS and acidity.

For these analysis, the following methods were employed

1. Juice percentage was calculated on weight basis, i.e., weight of the juice per 100g of fruit..
2. Titrable acidity - Titrymetry – A.O.A.C., 1970
3. Total Soluble Solids – A.O.A.C., 1970

4. EXPERIMENTAL RESULTS

The present study entitled “Variation in leaf nutrient status, yield and quality as affected by varying levels of N, P and K, method and time of application of fertilizers and sampling techniques on Kinnow” was carried out in farmer’s orchard, Farukh Nagar, Gurgaon District, Haryana and Tissue Nutrient Laboratory, National Professor Scheme, Division of Fruits and Horticultural Technology, Indian Agricultural Research Institute, New Delhi, during the period between February 1999 and January 2001.

The present study was conducted with four main experiments *viz.*,

Experiment No. 1 Effect of sampling techniques on tissue nutrient status of Kinnow.

Experiment No. 2 Effect of varying doses of fertilizers on tissue nutrient status, yield and quality of Kinnow.

Experiment No. 3 Effect of time of application of N fertilizer on tissue nutrient status of Kinnow.

Experiment No. 4 Effect of method of application of N fertilizer on tissue nutrient status of Kinnow.

Among these experiments Experiment No.1 was conducted under four sub experiments *viz.*,

Experiment No. 1(i). Effect of time of sampling on leaf nutrient status of Kinnow.

Experiment No. 1.(ii). Effect of position of leaves on leaf nutrient status of Kinnow.

Experiment No. 1.(iii). Effect of aspect of tree on leaf nutrient status of Kinnow.

Experiment No. 1.(iv) Effect of size of sampling on leaf nutrient status of Kinnow.

Experiment No.2 was conducted under three sub experiments.

Experiment No. 2.(i). Effect of varying doses of N on leaf nutrient status, yield and quality.

Experiment No. 2.(ii). Effect of varying doses of P on leaf nutrient status, yield and quality.

Experiment No. 2.(iii). Effect of varying doses of K on leaf nutrient status, yield and quality.

Initially soil samples were collected from the orchard and analysed for nutrient status from all the experimental blocks. The observations made and the results obtained are presented hereunder :

Table 1.1. Soil characteristics of Kinnow orchard

Depth (cm)	pH	EC (dsm^{-1})	O·C (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Ca (ppm)	Mg (ppm)	S (kg/ha)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Fe (ppm)
0-15	8.4	0.32	0.58	329.8	20.9	474	110.2	39.4	11.2	15.76	1.23	1.45	23.9
15-30	8.4	0.31	0.39	243.7	15.3	490	138.4	34.2	24.7	15.34	0.78	1.03	19.4
30-45	8.5	0.40	0.28	175.0	10.4	378	104.3	26.4	19.3	15.12	0.71	0.87	16.7
Mean	8.4	0.34	0.42	249.5	15.5	447.3	117.6	33.3	18.4	15.41	0.91	1.12	20.0
CD at %	0.1	0.09	0.17	24.3	6.3	13.8	16.3	9.4	4.5	0.41	0.32	0.09	3.4

4.1 Soil characters of Kinnow orchard

The soil characteristics of Kinnow orchard located at Farukh Nagar, Gurgaon District, Haryana are given in Table No.1.1. The soil pH was found to be saline at 8.4. EC has been found to be 0.34 dsm^{-1} . The organic carbon percentage has been found to be reducing from surface to deeper layers. Though at subsurface and deeper layers it has been found to be at low range at surface layer it has been found to be at medium range. The available N at surface layer has been found to be at medium range and at subsurface and deeper layers in low range. The available P on all three layers has been found to be at medium range. The exchangeable K on all three layers has been at high range. The exchangeable Ca and Mg have found to be at medium range in surface layer and low range at subsurface and deeper layers. Fe content has been found to be medium in all three layers.

The Mn in all three layers was found to be in high range. Zn and Cu in all three layers have been found to be in medium range.

4.2. Effect of sampling techniques on leaf nutrient status

4.2.1 Effect of time of sampling on leaf nutrient status

4.2.1.1 Effect on leaf primary nutrients

Nitrogen content in leaf has increased from February till April. Then it has dropped till June. From July onwards it has picked up till it reached the peak ins August. Again it has dropped till December. The stabilization period

Table 2.1. Effect of time of sampling on leaf nutrient status of Kinnow during 1999-2000

Treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Fe (ppm)
Feb. T ₁	2.28	0.13	1.42	3.70	0.55	0.28	23.6	10.9	6.9	100.8
Mar. T ₂	2.37	0.18	1.53	3.79	0.50	0.35	35.6	11.2	7.3	113.8
Apr. T ₃	2.61	0.16	1.56	3.85	0.42	0.37	28.2	12.3	7.7	94.2
May. T ₄	1.82	0.14	1.39	3.99	0.37	0.38	60.2	13.6	7.8	125.8
Jun. T ₅	1.79	0.12	1.24	4.12	0.33	0.35	43.7	14.5	8.4	123.2
Jul. T ₆	2.92	0.19	1.69	4.39	0.38	0.33	62.2	14.9	8.6	121.8
Aug. T ₇	2.96	0.18	1.72	4.49	0.43	0.42	65.8	13.9	9.5	130.6
Sep. T ₈	2.88	0.24	1.82	4.56	0.44	0.39	60.2	14.2	10.8	134.8
Oct. T ₉	2.37	0.26	1.85	4.67	0.42	0.35	40.3	13.8	10.2	122.4
Nov. T ₁₀	2.11	0.20	1.72	4.32	0.36	0.36	33.4	12.3	9.6	107.4
Dec. T ₁₁	1.82	0.16	1.46	3.82	0.31	0.30	36.2	13.4	7.3	101.3
Jan. T ₁₂	2.23	0.12	1.40	3.80	0.44	0.31	27.3	11.2	7.1	98.2
Mean	2.347	0.173	1.563	4.125	0.418	0.349	43.06	12.98	10.10	114.53
CD at 5 %	0.27	0.03	0.21	0.66	0.06	0.03	5.00	1.60	1.30	13.10

for leaf N has appeared between July to September. This kind of trend has been observed in both the years of study (1999-2000 and 2000-2001) (Fig.1).

Leaf phosphorus content has shown an upward trend in February and March but then on it has shown a decreasing trend till June. After June two peak periods have been appearing, a minor peak during July and August and a major peak during September and October (Fig.1).

Leaf potassium initially has increased till April then it has decreased till June, again it has increased till October. The stabilization period has appeared between July and November. After November leaf K has dropped. This trend has been observed in both the years of study (Fig.1).

4.2.1.2 Effect on leaf secondary nutrients

Leaf calcium content has increased from February to October. Then it has decreased. The stabilization period has occurred between June to November in both the years. Magnesium content in leaves has initially shown a decreasing trend from February to June. From July onwards it has shown an increasing trend till September. However, stabilization period has appeared between July to October in both the years.

From February to May the leaf sulphur content has increased then it has decreased till July. During August and September it has suddenly increased and stabilized there. However, after stabilization period the leaf S content has shown an irregular trend till December.

Table 2.2. Effect of time of sampling on leaf nutrient status of Kinnow during 2000-2001

Treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Fe (ppm)
Feb. T ₁	2.32	0.16	1.45	3.74	0.59	0.26	24.1	11.8	7.8	97.2
Mar. T ₂	2.39	0.20	1.58	3.78	0.49	0.36	36.2	12.3	7.9	114.2
Apr. T ₃	2.68	0.19	1.62	3.82	0.42	0.36	28.3	12.6	8.2	103.4
May. T ₄	1.86	0.15	1.33	4.16	0.38	0.38	58.2	13.8	8.4	131.2
Jun. T ₅	1.82	0.11	1.28	4.36	0.35	0.35	42.1	14.2	8.5	130.1
Jul. T ₆	2.90	0.21	1.67	4.50	0.39	0.32	65.8	14.3	8.6	128.3
Aug. T ₇	2.94	0.19	1.69	4.52	0.43	0.41	66.2	13.6	9.6	133.4
Sep. T ₈	2.93	0.26	1.73	4.69	0.45	0.38	58.4	14.2	10.4	135.6
Oct. T ₉	2.28	0.28	1.82	4.78	0.42	0.35	42.3	13.4	9.2	127.4
Nov. T ₁₀	2.12	0.18	1.76	4.42	0.38	0.36	35.6	12.6	9.0	108.5
Dec. T ₁₁	1.92	0.16	1.42	3.88	0.34	0.32	38.2	12.9	7.4	100.7
Jan. T ₁₂	2.27	0.11	1.38	3.79	0.42	0.30	29.4	11.6	6.8	98.3
Mean	2.369	0.182	1.561	4.203	0.421	0.346	43.73	13.11	8.48	117.36
CD at 5 %	0.29	0.02	0.16	0.50	0.06	0.05	6.00	1.30	0.90	16.60

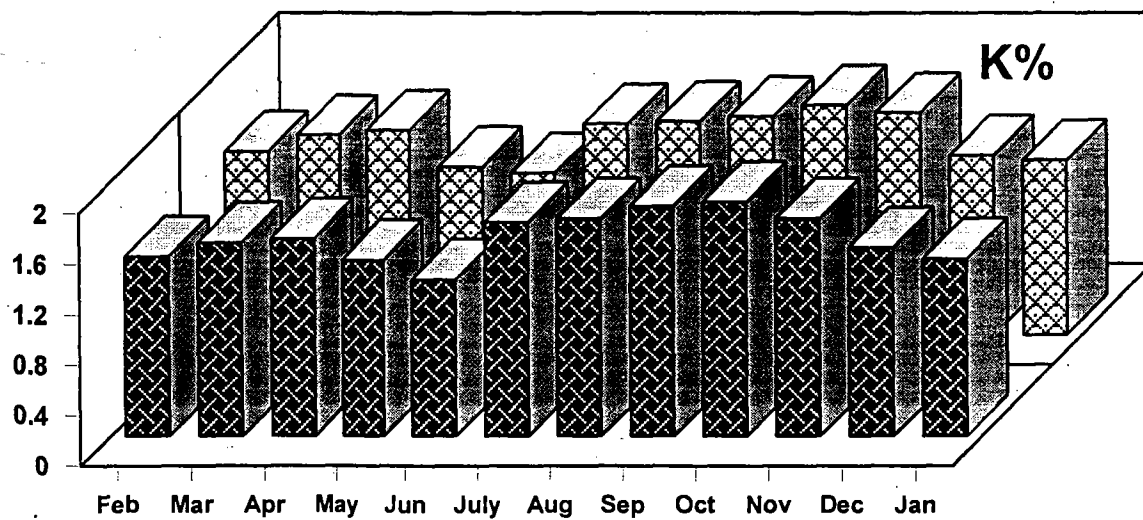
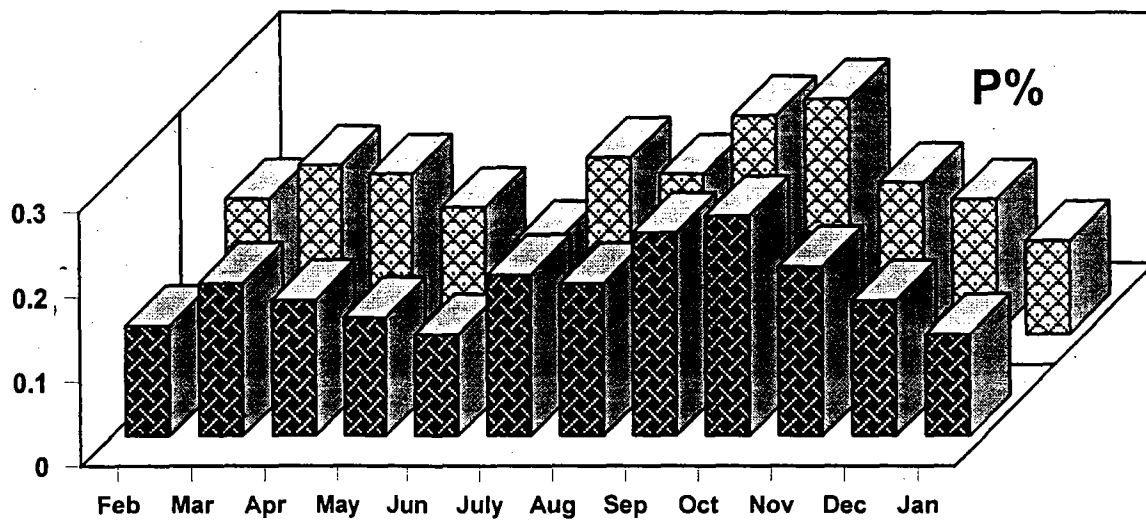
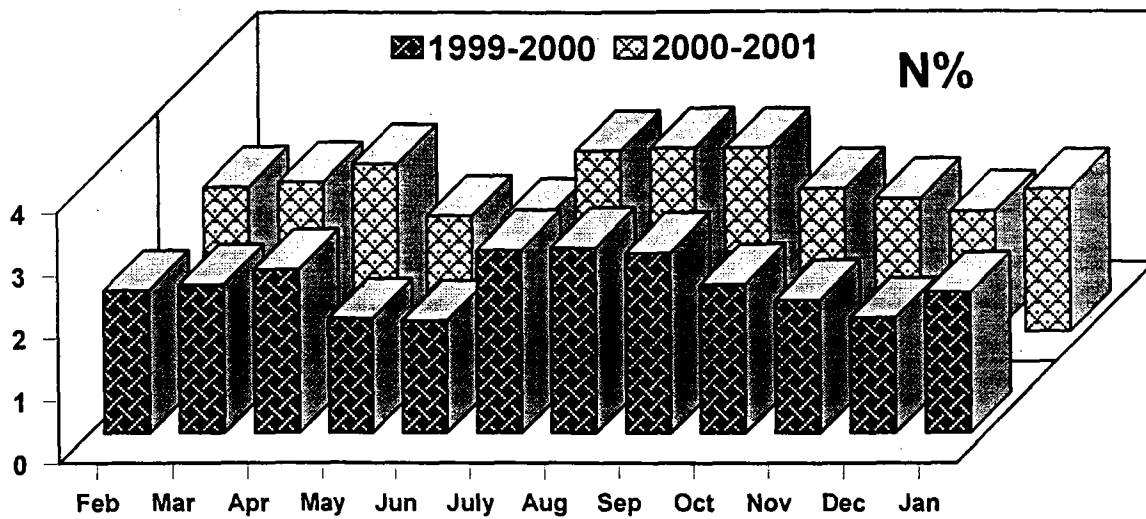


Fig. 1. Effect of time of sampling on leaf primary nutrient status

4.2.1.3 Effect on leaf micronutrients

From February to June Mn has shown an irregular trend. However, peak period as well as stabilization period have appeared during July and August.

The stabilization period for Zn has appeared to be one of the longest. It has started from May and ended in October. However, after July Zn has shown an irregular trend.

Leaf copper content has shown one of the highest regular trend. It has increased till September then on it has decreased till December. However, the stabilization period has differed between first year and second year of the study. In first year it has appeared between August and September. In second year it has appeared between August and October. For iron the stabilization period has appeared between May to October during both the years.

4.2.2 Effect of position of leaves on leaf nutrient status

The position of leaves has affected leaf nutrient contents during both the years of study. T₁ position has been found superior for all the nutrients except Ca. However, for P, Mg and Zn T₁ and T₂ have been found superior during first year. For S and Fe T₁ and T₂ have been found to be statistically at par in both the years. In Cu during second year T₁ and T₂ have been found to be at par. For Ca alone T₂ has been found superior (Tables 3.1; 3.2 and Fig.2).

Table 3.1. Effect of position of leaves on leaf nutrient status of Kinnow during 1999

Treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Fe (ppm)
T ₁	2.71	0.30	1.90	4.10	0.42	0.30	62.6	13.4	10.7	123.7
T ₂	2.39	0.29	1.42	4.30	0.40	0.29	43.9	12.7	9.9	121.6
T ₃	1.85	0.10	1.29	3.85	0.29	0.14	36.1	10.9	6.9	98.4
Mean	2.30	0.23	1.53	4.07	0.37	0.24	47.4	12.3	9.13	114.2
CD at 5 %	0.13	0.01	0.12	0.19	0.02	0.01	2.30	0.70	0.40	5.00

Table 3.2. Effect of position of leaves on leaf nutrient status of Kinnow during 2000

Treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Fe (ppm)
T ₁	2.60	0.29	1.72	4.42	0.51	0.40	60.4	14.9	10.6	131.3
T ₂	2.40	0.14	1.30	4.71	0.42	0.42	48.7	13.7	10.6	127.4
T ₃	1.71	0.10	1.14	3.71	0.29	0.30	35.4	9.3	7.7	97.9
Mean	2.22	0.18	1.38	4.27	0.41	0.37	48.0	12.60	9.61	118.52
CD at 5 %	0.10	0.02	0.16	0.19	0.03	0.02	3.30	0.50	0.30	6.60

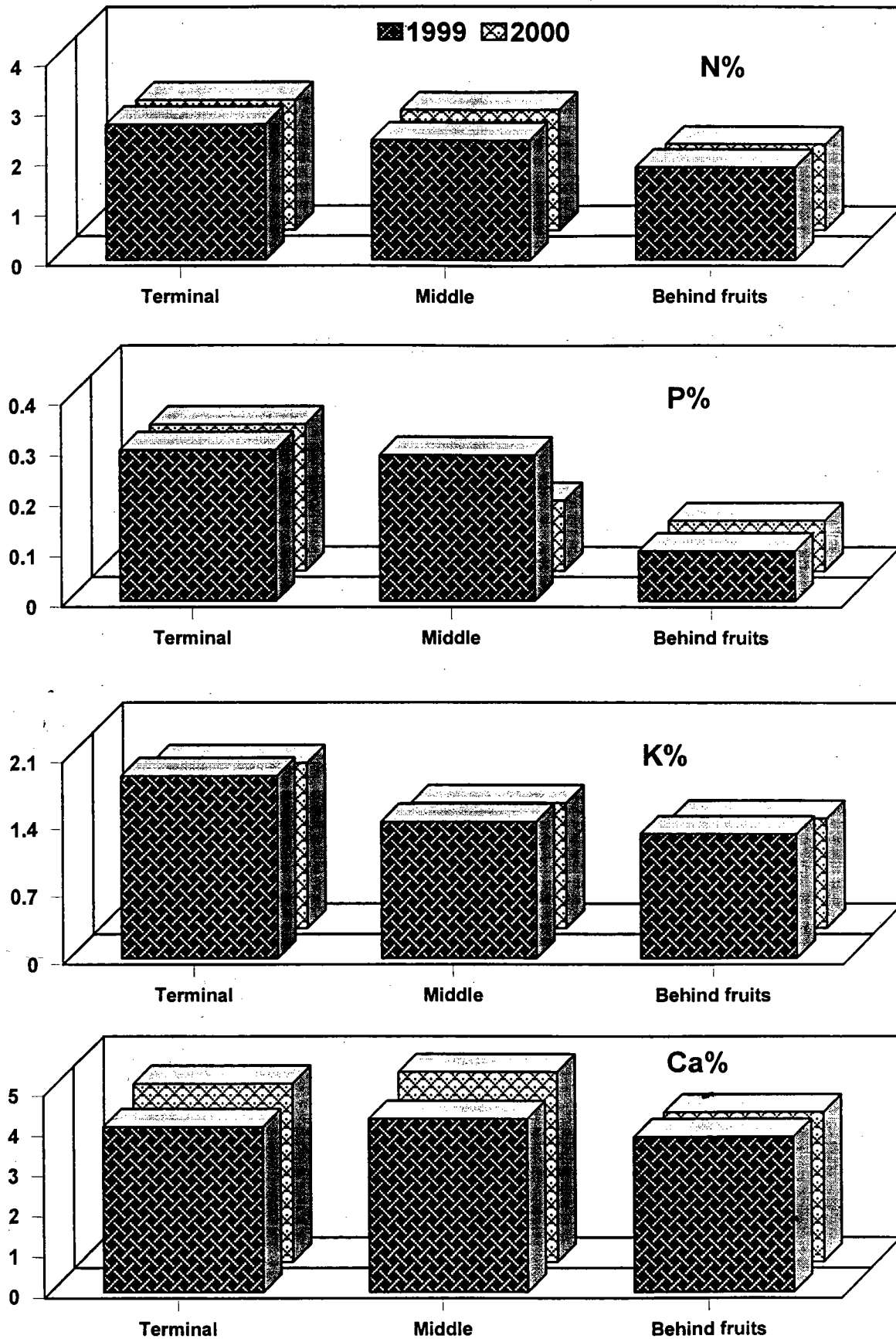


Fig. 2. Effect of position of leaves on N,P,K and Ca content

4.2.3 Effect of sample size on leaf nutrient status

4.2.3.1 Effect on leaf primary nutrients

Effect of sample size has not produced any detectable differences amongst the four treatments on leaf N content. All the four treatments have been found at par during their N content stabilization period, i.e., July to September (Tables No : 4.1 and 4.2).

Sample size has shown an irregular trend on leaf P content during stabilization period. None of the treatments can be conclusively said to be superior. However, mean data has shown that during first year T_1 and T_2 are inferior to T_3 and T_4 but the trend has been reversed during the second year (Tables No. 4.3 and 4.4).

The mean K value has shown that all the treatments are at par during stabilization period T_3 and T_4 has been found to be at par. However, amongst mean values T_3 has produced numerically higher values (Tables No. 4.5; 4.6 and Fig.3)

4.2.3.2 Effect on leaf secondary nutrients

Sample size has not affected Ca content in leaves. All the four treatments have been found at par during stabilization period (Table No. 4.7 and 4.8).

During the stabilization period the leaf Mg content has not shown any difference amongst the treatments. The mean Mg content also has been found to be statistically at par for all the treatments. (Table NO. 4.9 and 4.10)

Table 4.1. Effect of Sample size on leaf N (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	2.23	2.37	2.54	2.06	1.85	2.79	2.77	2.65	2.35	2.468
T ₂	2.34	2.48	2.61	2.14	1.81	2.82	2.84	2.74	2.48	2.473
T ₃	2.37	2.49	2.64	2.16	1.84	2.84	2.85	2.76	2.44	2.488
T ₄	2.33	2.37	2.62	2.16	1.79	2.82	2.85	2.72	2.44	2.456
Mean	2.318	2.428	2.603	2.280	1.822	2.818	2.827	2.718	2.428	-

CD at 5% = Season (A) = 0.160; Treatment (B) = 0.107

Table 4.2. Effect of Sample size on leaf N (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	2.24	2.36	2.57	2.00	1.76	2.71	2.73	2.64	2.32	2.372
T ₂	2.37	2.47	2.62	2.11	1.82	2.84	2.86	2.72	2.46	2.474
T ₃	2.41	2.48	2.65	2.16	1.92	2.86	2.87	2.73	2.44	2.502
T ₄	2.35	2.41	2.62	2.14	1.99	2.82	2.85	2.74	2.45	2.486
Mean	2.343	2.430	2.615	2.107	1.873	2.808	2.828	2.707	2.418	-

CD at 5% = Season (A) = 0.157; Treatment (B) = 0.105

Table 4.3. Effect of Sample size on leaf P (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.16	0.24	0.21	0.15	0.14	0.17	0.18	0.21	0.22	0.187
T ₂	0.17	0.24	0.22	0.16	0.14	0.17	0.17	0.22	0.24	0.192
T ₃	0.16	0.27	0.21	0.17	0.15	0.19	0.17	0.23	0.24	0.199
T ₄	0.19	0.29	0.25	0.16	0.13	0.16	0.16	0.20	0.22	0.196
Mean	0.170	0.260	0.222	0.160	0.140	0.173	0.170	0.215	0.230	-

CD at 5% = Season (A) = 0.017; Treatment (B) = 0.012

Table 4.4. Effect of Sample size on leaf P (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.18	0.25	0.23	0.16	0.16	0.17	0.17	0.28	0.29	0.210
T ₂	0.19	0.27	0.23	0.15	0.16	0.20	0.16	0.22	0.25	0.203
T ₃	0.16	0.24	0.21	0.16	0.17	0.18	0.15	0.24	0.25	0.196
T ₄	0.19	0.25	0.24	0.13	0.12	0.19	0.19	0.21	0.24	0.197
Mean	0.180	0.253	0.227	0.150	0.153	0.185	0.168	0.238	0.260	-

CD at 5% = Season (A) = 0.021; Treatment (B) = 0.015

Table 4.5. Effect of Sample size on leaf K (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	1.62	1.58	1.61	1.34	1.41	1.63	1.69	1.74	1.80	1.601
T ₂	1.63	1.67	1.72	1.38	1.42	1.67	1.72	1.81	1.89	1.657
T ₃	1.65	1.66	1.69	1.32	1.47	1.82	1.83	1.88	1.89	1.690
T ₄	1.57	1.63	1.71	1.38	1.48	1.83	1.85	1.88	1.87	1.689
Mean	1.612	1.635	1.682	1.356	1.445	1.737	1.773	1.827	1.862	-

CD at 5% = Season (A) = 0.128; Treatment (B) = 0.085

Table 4.6. Effect of Sample size on leaf K (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	1.57	1.58	1.62	1.32	1.33	1.65	1.69	1.75	1.78	1.588
T ₂	1.64	1.67	1.73	1.39	1.45	1.68	1.69	1.74	1.79	1.642
T ₃	1.69	1.71	1.74	1.28	1.44	1.59	1.72	1.81	1.84	1.647
T ₄	1.59	1.63	1.61	1.29	1.38	1.48	1.83	1.85	1.87	1.614
Mean	1.623	1.648	1.675	1.320	1.400	1.600	1.733	1.788	1.820	-

CD at 5% = Season (A) = 0.132; Treatment (B) = 0.092

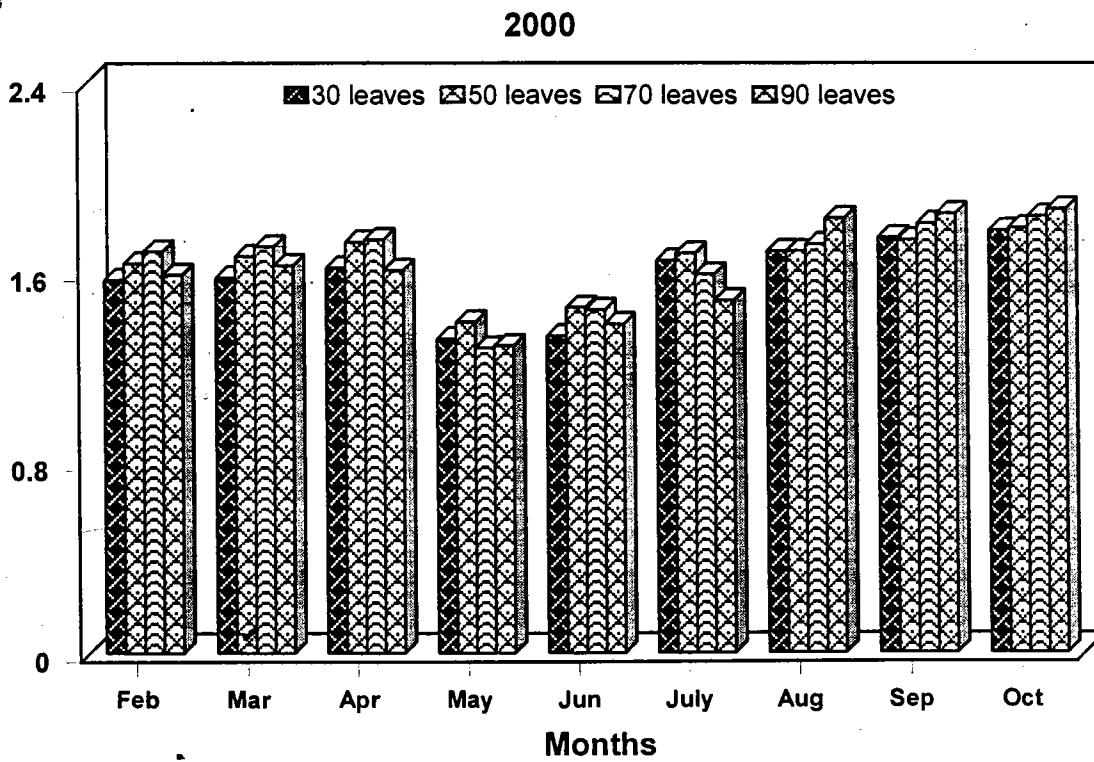
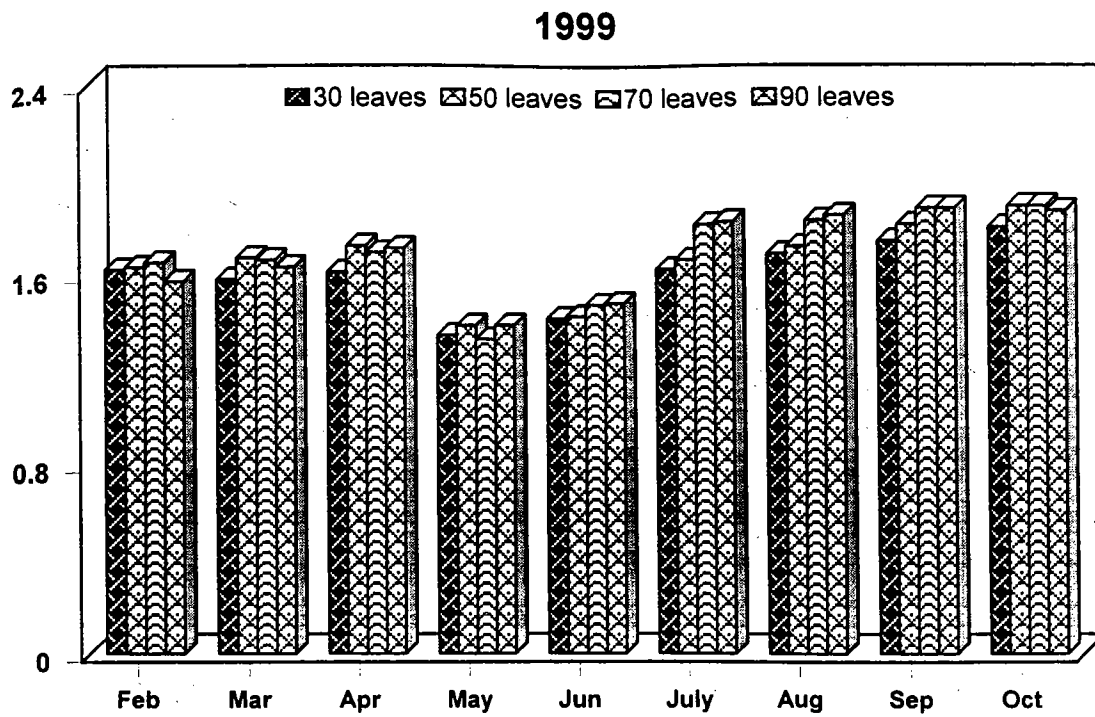


Fig. 3. Effect of sample size on leaf K (%) content

Table 4.7. Effect of Sample size on leaf Ca (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	3.72	3.75	3.81	3.98	4.12	4.38	4.41	4.44	4.69	4.144
T ₂	3.67	3.72	3.79	3.89	4.11	4.36	4.47	4.51	4.71	4.137
T ₃	3.63	3.69	3.73	3.82	4.04	4.27	4.45	4.52	4.79	4.104
T ₄	3.61	3.64	3.69	3.77	3.98	4.18	4.38	4.56	4.82	4.070
Mean	3.658	3.700	3.755	3.865	4.063	4.298	4.428	4.508	4.753	-

CD at 5% = Season (A) = 0.266; Treatment (B) = 0.177

Table 4.8. Effect of Sample size on leaf Ca (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	3.70	3.74	3.78	3.88	4.11	4.37	4.42	4.44	4.68	4.124
T ₂	3.64	3.71	3.78	3.87	4.11	4.35	4.48	4.52	4.75	4.134
T ₃	3.60	3.63	3.71	3.81	4.00	4.28	4.45	4.55	4.78	4.090
T ₄	3.57	3.61	3.69	3.78	3.98	4.18	4.36	4.55	4.89	4.068
Mean	3.627	3.673	3.740	3.835	4.050	4.295	4.428	4.515	4.775	-

CD at 5% = Season (A) = 0.210; Treatment (B) = 0.140

Table 4.9. Effect of Sample size on leaf Mg (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.51	0.43	0.41	0.36	0.37	0.38	0.43	0.44	0.41	0.416
T ₂	0.60	0.49	0.47	0.39	0.37	0.38	0.39	0.40	0.36	0.428
T ₃	0.62	0.57	0.49	0.41	0.39	0.41	0.42	0.43	0.36	0.456
T ₄	0.61	0.58	0.48	0.41	0.369	0.40	0.40	0.41	0.35	0.448
Mean	0.585	0.517	0.463	0.393	0.380	0.393	0.410	0.420	0.370	-

CD at 5% = Season (A) = 0.210; Treatment (B) = 0.140

Table 4.10. Effect of Sample size on leaf Mg (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.54	0.41	0.39	0.31	0.32	0.35	0.41	0.43	0.41	0.397
T ₂	0.57	0.44	0.42	0.38	0.39	0.35	0.39	0.40	0.35	0.410
T ₃	0.61	0.57	0.47	0.40	0.41	0.42	0.42	0.40	0.36	0.451
T ₄	0.61	0.57	0.48	0.39	0.41	0.42	0.43	0.42	0.35	0.453
Mean	0.583	0.497	0.440	0.370	0.383	0.385	0.413	0.413	0.367	-

CD at 5% = Season (A) = 0.134; Treatment (B) = 0.103

Table 4.11. Effect of Sample size on leaf S (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.25	0.31	0.36	0.39	0.54	0.38	0.35	0.31	0.34	0.337
T ₂	0.30	0.33	0.37	0.41	0.37	0.40	0.37	0.34	0.31	0.356
T ₃	0.27	0.33	0.36	0.37	0.33	0.38	0.35	0.30	0.34	0.337
T ₄	0.27	0.33	0.36	0.40	0.31	0.35	0.34	0.31	0.33	0.333
Mean	0.273	0.325	0.362	0.393	0.338	0.377	0.352	0.315	0.330	-

CD at 5% = Season (A) = 0.016; Treatment (B) = 0.011

Table 4.12. Effect of Sample size on leaf S (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.27	0.31	0.35	0.40	0.35	0.36	0.35	0.31	0.34	0.338
T ₂	0.29	0.30	0.35	0.37	0.32	0.31	0.31	0.35	0.30	0.322
T ₃	0.30	0.31	0.36	0.39	0.36	0.31	0.31	0.35	0.32	0.334
T ₄	0.27	0.32	0.38	0.39	0.34	0.36	0.32	0.30	0.28	0.329
Mean	0.283	0.310	0.360	0.388	0.343	0.335	0.323	0.328	0.310	-

CD at 5% = Season (A) = 0.020; Treatment (B) = 0.014

The leaf S content has shown conflicting results in different years. In the first year T₂ has shown higher values during stabilization period as well as in its term value. However, in second year the trend has been exactly opposite and T₂ has recorded lowest values. Amongst treatments, T₁ has shown consistent result in both the years during the stabilization period (Table Nos. 4.11 and 4.12).

4.2.3.3 Effect on leaf micronutrients

T₃ and T₄ have shown higher as well as consistent results for leaf Mn content during its stabilization period in both the years of study. Amongst T₃ and T₄ latter has shown more consistency throughout the stabilization period. Nevertheless, the mean Mn value has been found to be at par for all the treatments (Table No. 4.13; 4.14 and Fig. 4).

Leaf Zn content has not been affected by sample size. On both years of study all the four treatments have been found to be at par. There has been a sudden increase in Cu content during September in both the years. So when comparing the peak values, even though T₁, T₂ and T₄ have been found superior in first year, only T₂ and T₄ have been proved superior in second year. However, during stabilization period i.e. June and July T₃ has been found superior (Tables No. 4.15 to 4.18).

The leaf Fe content has not shown any remarkable difference amongst the treatments. However T₄ has shown higher level of consistency in both the years during stabilization period (Tables No. 4.19 and 4.20).

Table 4.13. Effect of Sample size on leaf Mn (ppm) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	24.3	33.8	28.5	54.3	41.7	55.8	58.3	53.1	41.2	43.44
T ₂	21.2	36.2	29.1	49.8	41.3	60.1	61.2	48.9	34.2	42.44
T ₃	25.1	31.2	27.3	56.1	43.0	63.2	65.1	54.2	33.2	44.27
T ₄	23.0	33.4	29.6	54.1	43.8	61.4	63.8	60.1	35.6	44.98
Mean	23.40	33.65	28.63	53.56	42.45	60.13	62.10	54.08	36.05	-

CD at 5% = Season (A) = 3.82; Treatment (B) = 2.53

Table 4.14. Effect of Sample size on leaf Mn (ppm) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	23.9	34.4	27.6	55.1	43.2	56.2	58.3	53.2	44.1	44.00
T ₂	22.4	36.1	29.2	46.8	40.4	57.3	59.4	44.5	36.2	42.58
T ₃	24.6	33.8	28.5	53.2	47.1	61.1	63.2	57.3	35.4	44.91
T ₄	25.1	32.1	29.2	55.2	46.4	61.3	62.9	55.1	37.4	44.98
Mean	24.00	34.10	28.63	55.33	44.28	58.98	60.95	52.53	38.28	-

CD at 5% = Season (A) = 3.59; Treatment (B) = 2.39

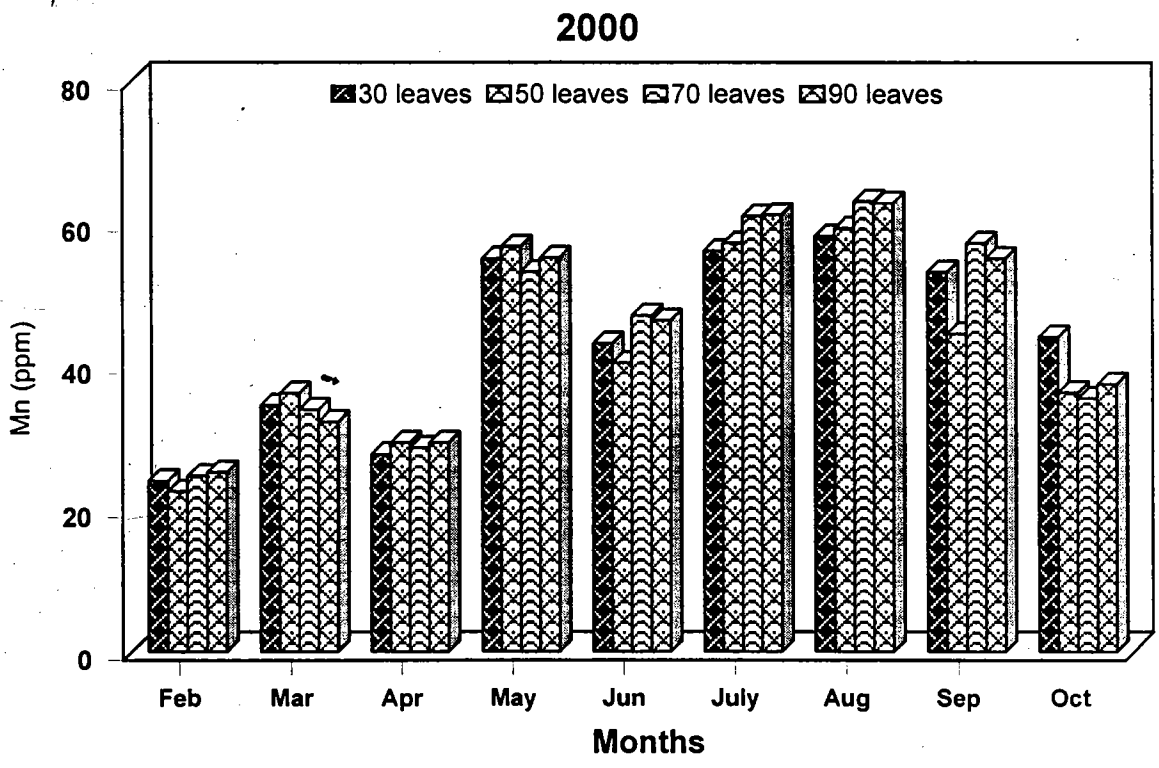
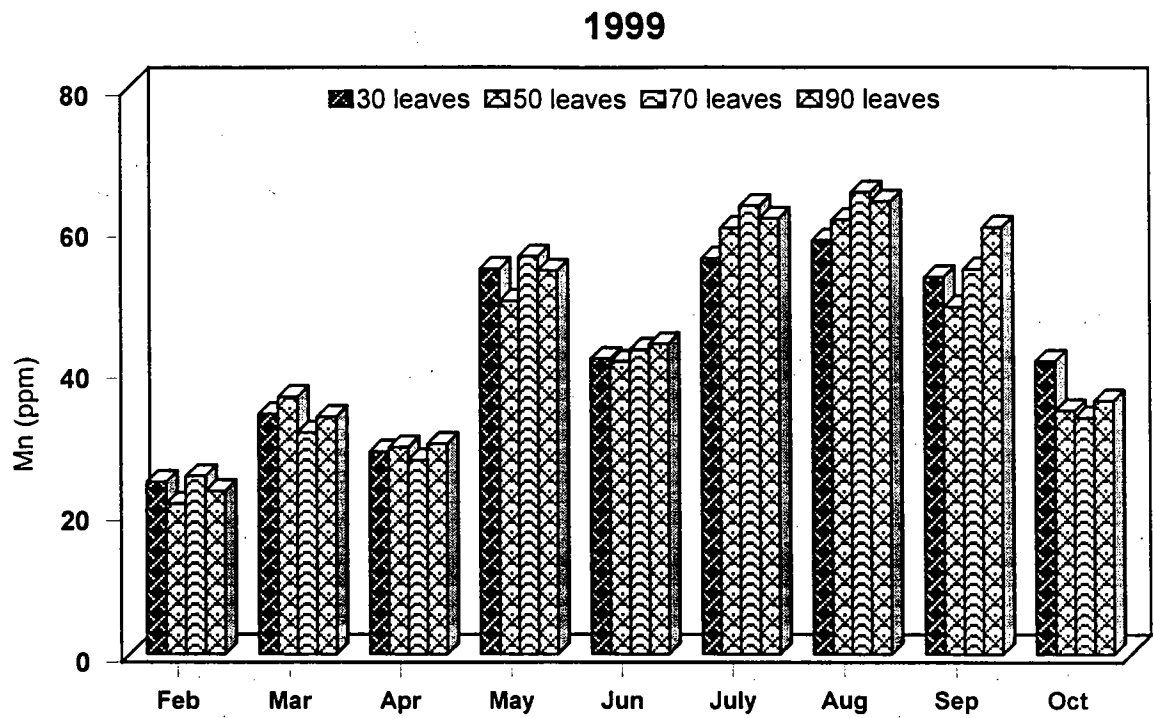


Fig. 4. Effect of sample size of leaf Mn (ppm) content

Table 4.15. Effect of Sample size on leaf Zn (ppm) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	11.8	12.3	12.7	13.5	14.4	14.2	13.9	13.6	13.1	13.28
T ₂	11.2	12.3	12.9	13.8	14.1	14.5	13.7	14.2	13.8	13.39
T ₃	10.8	11.8	12.3	12.6	13.8	14.6	14.5	13.9	13.6	13.10
T ₄	12.1	12.9	13.1	13.5	13.8	14.1	14.0	13.7	13.2	13.38
Mean	11.48	12.33	12.75	13.35	14.03	14.35	14.03	13.85	13.43	-

CD at 5% = Season (A) = 0.98; Treatment (B) = 0.66

Table 4.16. Effect of Sample size on leaf Zn (ppm) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	11.4	12.3	12.7	13.5	14.2	14.0	13.8	13.8	13.4	13.23
T ₂	11.7	12.8	13.2	13.7	14.2	14.1	14.2	13.1	12.8	13.31
T ₃	11.6	11.9	12.4	13.1	13.6	14.2	14.2	13.7	13.6	13.14
T ₄	11.9	12.9	13.2	13.6	13.8	14.4	14.5	13.4	13.0	13.41
Mean	11.65	12.48	12.88	13.48	13.95	14.18	14.18	13.50	13.20	-

CD at 5% = Season (A) = 0.88; Treatment (B) = 0.58

Table 4.17. Effect of Sample size on leaf Cu (ppm) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	7.8	8.2	8.3	8.5	8.7	8.8	9.5	10.9	9.3	8.89
T ₂	7.9	8.5	8.3	8.4	8.6	8.9	9.1	11.2	9.5	8.93
T ₃	7.6	7.9	8.2	8.5	8.6	9.6	10.9	9.7	9.1	8.90
T ₄	7.3	7.8	7.9	8.3	8.5	8.9	10.3	11.2	9.2	8.82
Mean	7.65	8.10	8.18	8.43	8.60	9.05	9.95	10.75	9.28	-

CD at 5% = Season (A) = 0.73; Treatment (B) = 0.49

Table 4.18. Effect of Sample size on leaf Cu (ppm) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	7.6	7.7	8.1	8.3	8.5	8.6	9.2	10.7	9.5	8.69
T ₂	7.6	8.1	8.2	8.6	8.8	8.9	9.4	11.4	9.6	8.96
T ₃	7.5	7.7	8.4	8.5	8.6	9.5	10.4	9.9	9.3	8.87
T ₄	7.7	7.8	8.2	8.3	8.7	8.9	10.2	11.8	9.1	8.97
Mean	7.60	7.83	8.23	8.43	8.65	8.98	9.80	10.95	9.38	-

CD at 5% = Season (A) = 0.57; Treatment (B) = 0.38

Table 4.19. Effect of Sample size on leaf Fe (ppm) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	109.0	125.4	88.3	122.4	125.4	126.2	138.9	139.5	122.5	121.96
T ₂	104.6	120.4	83.0	100.2	113.8	134.0	140.8	143.6	131.4	119.09
T ₃	101.4	110.3	81.2	131.4	119.7	121.6	133.6	136.4	120.2	117.31
T ₄	100.7	110.6	79.6	113.8	127.6	130.4	136.5	138.1	127.8	118.34
Mean	103.93	116.68	83.03	116.95	121.63	128.05	137.45	139.40	125.48	-

CD at 5% = Season (A) = 7.75; Treatment (B) = 5.16

Table 4.20. Effect of Sample size on leaf Fe (ppm) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	107.6	120.4	82.3	121.4	121.9	122.3	130.8	126.4	135.3	118.71
T ₂	107.3	122.6	85.4	105.6	116.2	128.3	130.2	138.2	139.1	119.21
T ₃	99.7	118.4	85.2	130.4	123.2	124.6	126.8	132.7	136.1	119.68
T ₄	102.1	109.2	78.8	119.5	125.2	132.1	135.6	131.2	125.4	117.68
Mean	104.18	117.65	82.93	119.23	121.63	126.83	130.85	132.13	133.98	-

CD at 5% = Season (A) = 7.44; Treatment (B) = 4.96

4.2.4 Effect of aspect of tree on leaf nutrient status

4.2.4.1. Effect on leaf primary nutrients

The N content has not been affected much by the directions of the tree sampling. However T₃ and T₄ have shown consistently higher values during July in both the years i.e. during stabilization period (Table No. 5.1 and 5.2).

The mean value of P content has shown that, except T₂ all other treatments have been higher and have been found to be at par. However, T₂ has been found at par with T₁. Amongst the season October month has shown highest values in all treatments. However during stabilization period T₂ shown remarkable consistency during both the years of study (Tables No. 5.3 and 5.4).

The aspect of tree has not given a conclusive trend in leaf K percentage. At the same time even though T₃ and T₄ have been found at par on both the years T₄ has shown numerically higher values and has produced highly consistent values (Tables No. 5.5 and 5.6).

4.2.4.2 Effect on leaf secondary nutrients

The aspect of tree has shown highly uniform Ca values for all the treatments during stabilization period in both years of study. The mean Ca values for all the treatments also have been found to be at par (Tables No.5.7 and 5.8).

The mean Mg values have been found to be at par and the aspect of tree has not affected it. However, during stabilization period of May to July it has

Table 5.1. Effect of aspect of tree on leaf N (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	2.28	2.37	2.49	1.69	1.67	2.69	2.85	2.81	2.34	2.354
T ₂	2.31	2.36	2.51	1.69	1.66	2.68	2.78	2.77	2.35	2.346
T ₃	2.36	2.39	2.54	1.76	1.73	2.91	2.84	2.81	2.67	2.446
T ₄	2.34	2.38	2.55	1.79	1.75	2.89	2.85	2.82	2.65	2.447
Mean	2.323	2.375	2.522	1.733	1.703	2.793	2.830	2.803	2.503	-

CD at 5% = Season (A) = 0.201; Treatment (B) = 0.134

Table 5.2. Effect of aspect of tree on leaf N (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T	2.27	2.37	2.50	1.69	1.67	2.65	2.85	2.84	2.37	2.357
T ₂	2.34	2.36	2.58	1.71	1.62	2.74	2.79	2.76	2.39	2.366
T ₃	2.37	2.40	2.52	1.78	1.75	2.95	2.89	2.83	2.64	2.459
T ₄	2.36	2.37	2.58	1.80	1.75	2.91	2.85	2.82	2.65	2.454
Mean	2.335	2.375	2.545	1.745	1.697	2.813	2.845	2.813	2.513	-

CD at 5% = Season (A) = 0.157; Treatment (B) = 0.105

Table 5.3. Effect of aspect of tree on leaf P (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.19	0.27	0.24	0.15	0.13	0.22	0.21	0.22	0.25	0.209
T ₂	0.17	0.25	0.24	0.16	0.13	0.20	0.19	0.21	0.24	0.201
T ₃	0.21	0.29	0.27	0.15	0.13	0.20	0.19	0.22	0.23	0.212
T ₄	0.21	0.27	0.27	0.15	0.13	0.20	0.19	0.20	0.23	0.207
Mean	0.195	0.270	0.255	0.153	0.130	0.205	0.195	0.213	0.238	-

CD at 5% = Season (A) = 0.018; Treatment (B) = 0.007

Table 5.4. Effect of aspect of tree on leaf P (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.20	0.27	0.25	0.15	0.14	0.21	0.21	0.21	0.27	0.215
T ₂	0.18	0.24	0.22	0.18	0.15	0.20	0.19	0.21	0.24	0.201
T ₃	0.22	0.29	0.27	0.14	0.12	0.22	0.19	0.24	0.27	0.221
T ₄	0.21	0.28	0.26	0.17	0.14	0.21	0.20	0.24	0.25	0.221
Mean	0.202	0.270	0.250	0.160	0.138	0.210	0.198	0.225	0.258	-

CD at 5% = Season (A) = 0.027; Treatment (B) = 0.010

Table 5.5. Effect of aspect of tree on leaf K (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	1.37	1.47	1.52	1.29	1.18	1.65	1.67	1.73	1.79	1.519
T ₂	1.41	1.52	1.53	1.38	1.26	1.60	1.68	1.69	1.72	1.532
T ₃	1.49	1.51	1.58	1.39	1.27	1.61	1.64	1.67	1.73	1.543
T ₄	1.44	1.53	1.58	1.36	1.23	1.64	1.73	1.74	1.75	1.556
Mean	1.427	1.507	1.552	1.355	1.235	1.625	1.680	1.708	1.748	-

CD at 5% = Season (A) = 0.085; Treatment (B) = 0.066

Table 5.6. Effect of aspect of tree on leaf K (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	1.41	1.49	1.52	1.32	1.21	1.59	1.62	1.73	1.77	1.518
T ₂	1.39	1.51	1.54	1.37	1.28	1.61	1.63	1.74	1.75	1.536
T ₃	1.48	1.47	1.55	1.39	1.23	1.64	1.65	1.69	1.71	1.534
T ₄	1.45	1.52	1.57	1.35	1.20	1.59	1.71	1.76	1.76	1.546
Mean	1.433	1.498	1.545	1.358	1.230	1.608	1.653	1.730	1.748	-

CD at 5% = Season (A) = 0.116; Treatment (B) = 0.094

Table 5.7. Effect of aspect of tree on leaf Ca (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	3.61	3.58	3.77	4.08	4.33	4.39	4.48	4.51	4.54	4.143
T ₂	3.27	3.56	3.63	4.11	4.17	4.32	4.37	4.57	4.61	4.068
T ₃	3.66	3.72	3.80	4.19	4.28	4.39	4.47	4.59	4.61	4.190
T ₄	3.72	3.76	3.81	4.15	4.38	4.49	4.53	4.67	4.69	4.244
Mean	3.565	3.655	3.752	4.133	4.290	4.397	4.462	4.585	4.612	-

CD at 5% = Season (A) = 0.279; Treatment (B) = 0.186

Table 5.8. Effect of aspect of tree on leaf Ca (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	3.69	3.58	3.70	3.90	4.12	4.39	4.41	4.53	4.46	4.087
T ₂	3.41	3.54	3.57	3.93	4.19	4.38	4.47	4.51	4.60	4.067
T ₃	3.64	3.65	3.73	3.90	4.19	4.36	4.46	4.51	4.63	4.119
T ₄	3.69	3.69	3.86	4.17	4.31	4.39	4.51	4.57	4.60	4.199
Mean	3.608	3.615	3.715	3.975	4.203	4.380	4.463	4.530	4.573	-

CD at 5% = Season (A) = 0.289; Treatment (B) = 0.193

Table 5.9. Effect of aspect of tree on leaf Mg (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.58	0.52	0.44	0.40	0.36	0.39	0.43	0.42	0.39	0.437
T ₂	0.62	0.56	0.49	0.42	0.40	0.41	0.44	0.39	0.35	0.453
T ₃	0.59	0.52	0.45	0.41	0.40	0.42	0.45	0.41	0.39	0.449
T ₄	0.59	0.52	0.47	0.41	0.42	0.44	0.45	0.41	0.33	0.449
Mean	0.595	0.530	0.463	0.410	0.395	0.415	0.443	0.408	0.365	-

CD at 5% = Season (A) = 0.027; Treatment (B) = 0.021

Table 5.10. Effect of aspect of tree on leaf Mg (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.57	0.53	0.47	0.43	0.40	0.42	0.44	0.42	0.37	0.450
T ₂	0.60	0.54	0.45	0.41	0.41	0.39	0.45	0.44	0.39	0.453
T ₃	0.57	0.54	0.48	0.41	0.45	0.43	0.48	0.41	0.31	0.453
T ₄	0.55	0.53	0.47	0.42	0.44	0.45	0.45	0.39	0.32	0.447
Mean	0.573	0.535	0.467	0.418	0.425	0.423	0.455	0.415	0.348	-

CD at 5% = Season (A) = 0.030; Treatment (B) = 0.024

Table 5.11. Effect of aspect of tree on leaf S (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.31	0.32	0.37	0.40	0.34	0.32	0.41	0.38	0.33	0.353
T ₂	0.38	0.33	0.36	0.39	0.34	0.32	0.39	0.35	0.36	0.357
T ₃	0.42	0.42	0.42	0.41	0.37	0.35	0.42	0.37	0.35	0.392
T ₄	0.41	0.43	0.44	0.45	0.42	0.32	0.42	0.41	0.31	0.400
Mean	0.380	0.375	0.398	0.413	0.367	0.327	0.411	0.378	0.338	-

CD at 5% = Season (A) = 0.026; Treatment (B) = 0.017

Table 5.12. Effect of aspect of tree on leaf S (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.36	0.37	0.39	0.42	0.37	0.31	0.38	0.35	0.34	0.364
T ₂	0.43	0.45	0.46	0.48	0.40	0.34	0.35	0.32	0.30	0.392
T ₃	0.39	0.41	0.43	0.43	0.39	0.37	0.44	0.39	0.38	0.403
T ₄	0.41	0.34	0.35	0.38	0.40	0.33	0.47	0.44	0.36	0.387
Mean	0.398	0.393	0.408	0.428	0.390	0.338	0.410	0.375	0.345	-

CD at 5% = Season (A) = 0.032; Treatment (B) = 0.021

been found that T₃ and T₄ are consistently superior over T₂ and T₁ (Table No. 5.9 and 5.10).

T₃ and T₄ have shown consistent higher mean S values than other treatments, even though in second year T₂ also has been found to be at par with T₃ and T₄. However, during the peak period, i.e., August T₄ has produced consistent values in both the years followed by T₃ (Tables No. 5.11 and 5.12).

4.2.4.3 Effect on leaf micronutrients

Mean leaf Mn content has shown that there is no difference amongst treatments. However, during stabilization period, i.e., July to September treatments have shown differences. Amongst treatments T₃ and T₄ have proved to be superior and have been found to be at par (Tables No. 5.13 and 5.14).

On both the years the stabilization period for leaf Zn has been appearing between June and October. Amongst treatments, except T₃, all other treatments have shown fair amount of consistency in their values in both the years throughout the stabilization period. However, mean value consistency has been highest in T₄, though it is at par with other treatments. T₃ and T₄ have produced numerically lower values (Tables No. 5.15; 5.16 and Fig.5).

For Cu, consistent stabilization period on both the years has not been observed. However, on both the years September has shown peak values in all treatments and stabilization period has swifited towards September and October. Amongst treatments T₁ has shown consistent higher values followed by T₂

Table 5.13. Effect of aspect of tree on leaf Mn (ppm) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	23.5	35.8	27.3	57.8	49.8	60.1	60.7	57.9	40.1	45.89
T ₂	22.4	33.1	27.0	56.2	49.1	58.2	59.4	58.1	37.3	44.53
T ₃	20.3	35.	26.6	56.7	48.9	61.5	62.3	60.3	39.9	45.72
T ₄	23.2	33.7	27.5	56.1	48.3	61.3	63.8	61.4	38.8	46.01
Mean	22.35	34.43	27.10	56.70	49.03	60.28	61.53	59.43	39.03	-

CD at 5% = Season (A) = 2.23; Treatment (B) = 1.48

Table 5.14. Effect of aspect of tree on leaf Mn (ppm) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	23.6	35.4	25.4	57.9	49.1	59.4	63.2	59.2	41.7	46.11
T ₂	27.1	34.6	26.7	56.7	51.2	57.9	59.2	55.4	42.1	45.66
T ₃	22.9	34.1	29.3	59.1	45.3	63.4	65.9	59.3	41.9	46.79
T ₄	24.2	33.9	25.3	59.2	47.3	63.9	63.9	61.8	40.3	46.64
Mean	24.45	34.50	26.68	58.23	48.23	61.15	63.05	59.28	41.50	-

CD at 5% = Season (A) = 3.77; Treatment (B) = 2.51

Table 5.15. Effect of aspect of tree on leaf Zn (ppm) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	11.3	11.9	12.3	12.8	13.9	14.2	13.8	14.2	13.2	13.07
T ₂	11.6	11.8	12.4	12.9	13.8	14.0	13.6	14.4	13.7	13.13
T ₃	10.6	10.9	11.4	12.4	12.9	13.3	12.9	13.2	12.9	12.28
T ₄	9.9	10.3	11.7	12.6	13.2	14.7	14.5	14.8	13.8	12.83
Mean	10.85	11.23	11.95	12.68	13.45	14.05	13.70	14.15	13.40	-

CD at 5% = Season (A) = 1.03; Treatment (B) = 0.69

Table 5.16. Effect of aspect of tree on leaf Zn (ppm) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	11.4	12.4	12.5	12.6	13.6	14.1	13.8	13.7	13.4	13.06
T ₂	11.7	11.9	12.1	12.8	13.4	14.1	13.6	14.2	13.4	13.02
T ₃	11.7	12.1	12.3	12.4	13.1	13.6	12.6	13.4	12.9	12.68
T ₄	10.9	11.3	11.4	12.3	13.2	14.6	14.2	14.7	13.1	12.86
Mean	11.43	11.93	12.08	12.53	13.33	14.10	13.55	14.00	13.20	-

CD at 5% = Season (A) = 0.99; Treatment (B) = 0.57

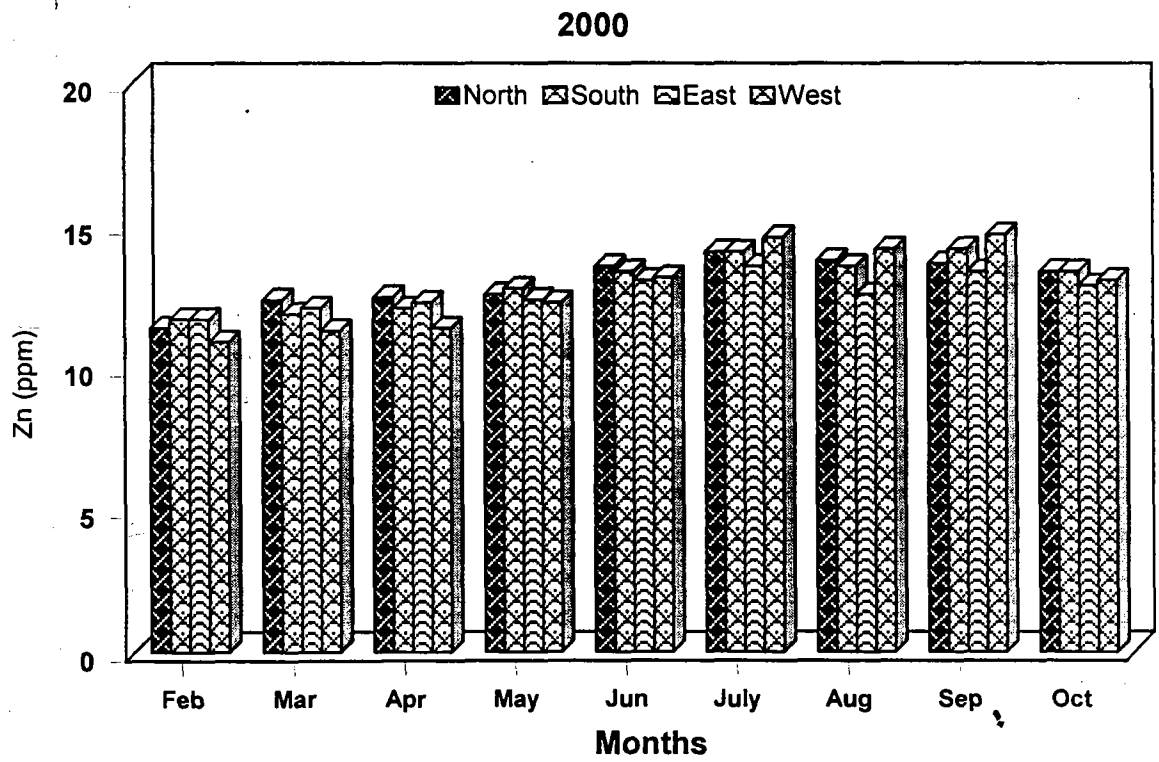
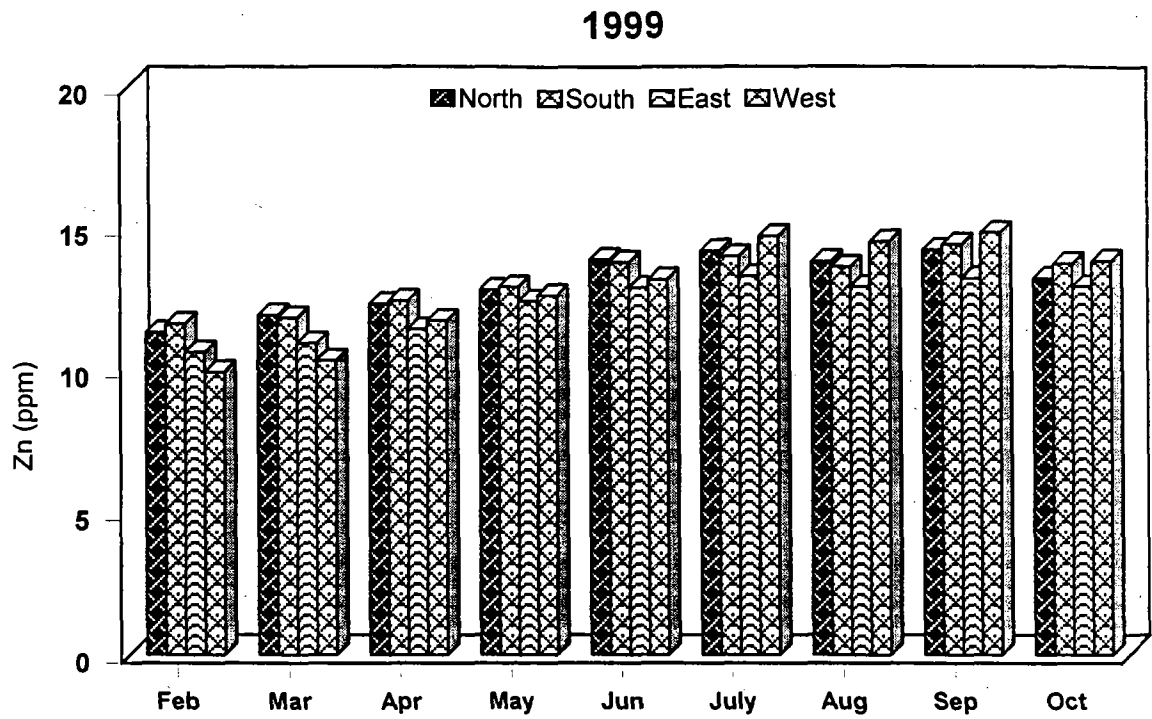


Fig. 5. Effect of aspect of tree on leaf Zn (ppm) content

Table 5.17. Effect of aspect of tree on leaf Cu (ppm) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	7.5	7.8	8.0	8.3	8.6	8.7	9.1	9.9	9.6	8.61
T ₂	7.1	7.4	7.6	7.8	8.2	8.4	8.8	9.8	8.7	8.20
T ₃	6.9	7.3	7.5	7.9	8.0	8.2	8.5	9.5	9.2	8.11
T ₄	6.9	6.9	7.9	8.1	8.2	8.4	8.9	9.4	9.1	8.20
Mean	7.10	7.35	7.75	8.03	8.25	8.43	8.83	9.65	9.15	-

CD at 5% = Season (A) = 0.64; Treatment (B) = 0.50

Table 5.18. Effect of aspect of tree on leaf Cu (ppm) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	7.3	7.8	8.1	8.5	8.6	8.8	9.2	9.7	9.5	8.61
T ₂	7.1	7.7	8.1	8.4	8.6	8.8	9.0	9.3	9.1	8.46
T ₃	7.4	7.5	7.7	7.7	8.5	8.9	9.3	9.5	9.4	8.43
T ₄	7.0	7.3	7.9	8.3	8.4	8.6	8.7	9.2	9.2	8.29
Mean	7.20	7.57	7.95	8.23	8.53	8.78	9.05	9.43	9.30	-

CD at 5% = Season (A) = 0.54; Treatment (B) = 0.36

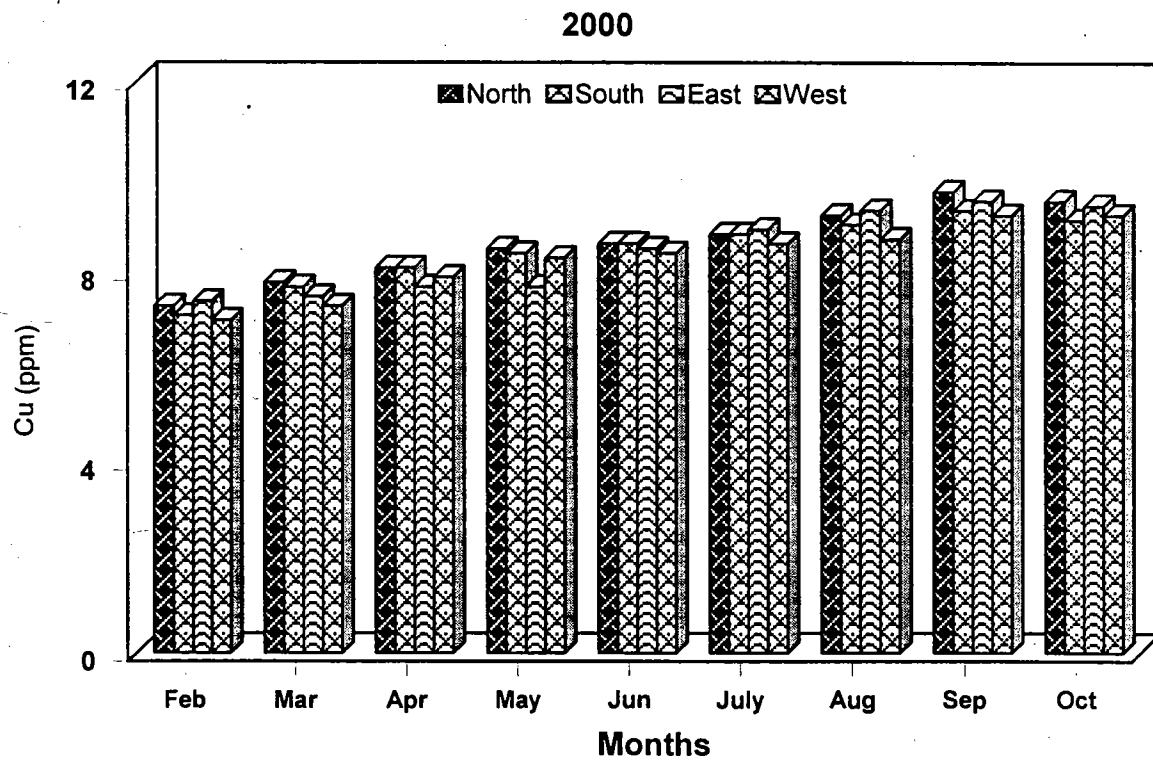
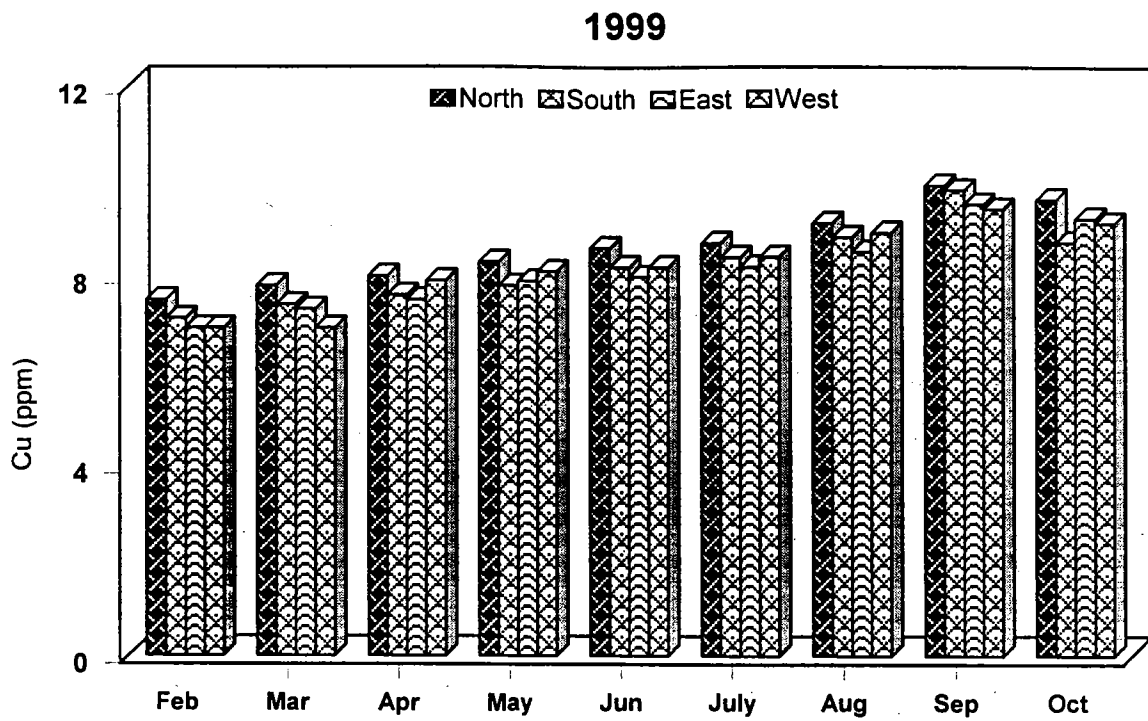


Fig. 6. Effect of aspect of tree on leaf Cu (ppm) content

Table 5.19. Effect of aspect of tree on leaf Fe (ppm) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	100.2	107.8	91.7	123.6	120.4	105.6	118.2	119.3	103.4	110.02
T ₂	93.2	101.2	98.3	102.6	101.7	105.3	121.3	127.4	119.4	107.82
T ₃	97.3	109.3	104.2	107.8	101.3	104.6	114.7	121.3	104.3	107.20
T ₄	94.6	117.3	106.5	109.9	100.8	103.4	110.4	118.6	107.5	107.67
Mean	96.33	108.90	100.18	110.98	106.05	104.73	116.15	121.65	108.65	-

CD at 5% = Season (A) = 8.60; Treatment (B) = 5.73

Table 5.20. Effect of aspect of tree on leaf Fe (ppm) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	100.9	103.4	99.8	121.4	120.8	109.3	117.6	121.5	104.8	111.06
T ₂	97.1	101.4	100.7	107.3	100.4	103.8	126.5	128.1	117.4	109.19
T ₃	98.3	101.4	100.4	117.4	101.4	103.2	115.5	127.6	101.4	106.96
T ₄	97.8	114.3	106.5	110.8	99.3	107.4	110.8	121.3	108.7	108.51
Mean	98.53	105.13	105.85	114.23	105.93	105.93	116.60	124.63	108.00	-

CD at 5% = Season (A) = 9.08; Treatment (B) = 6.06

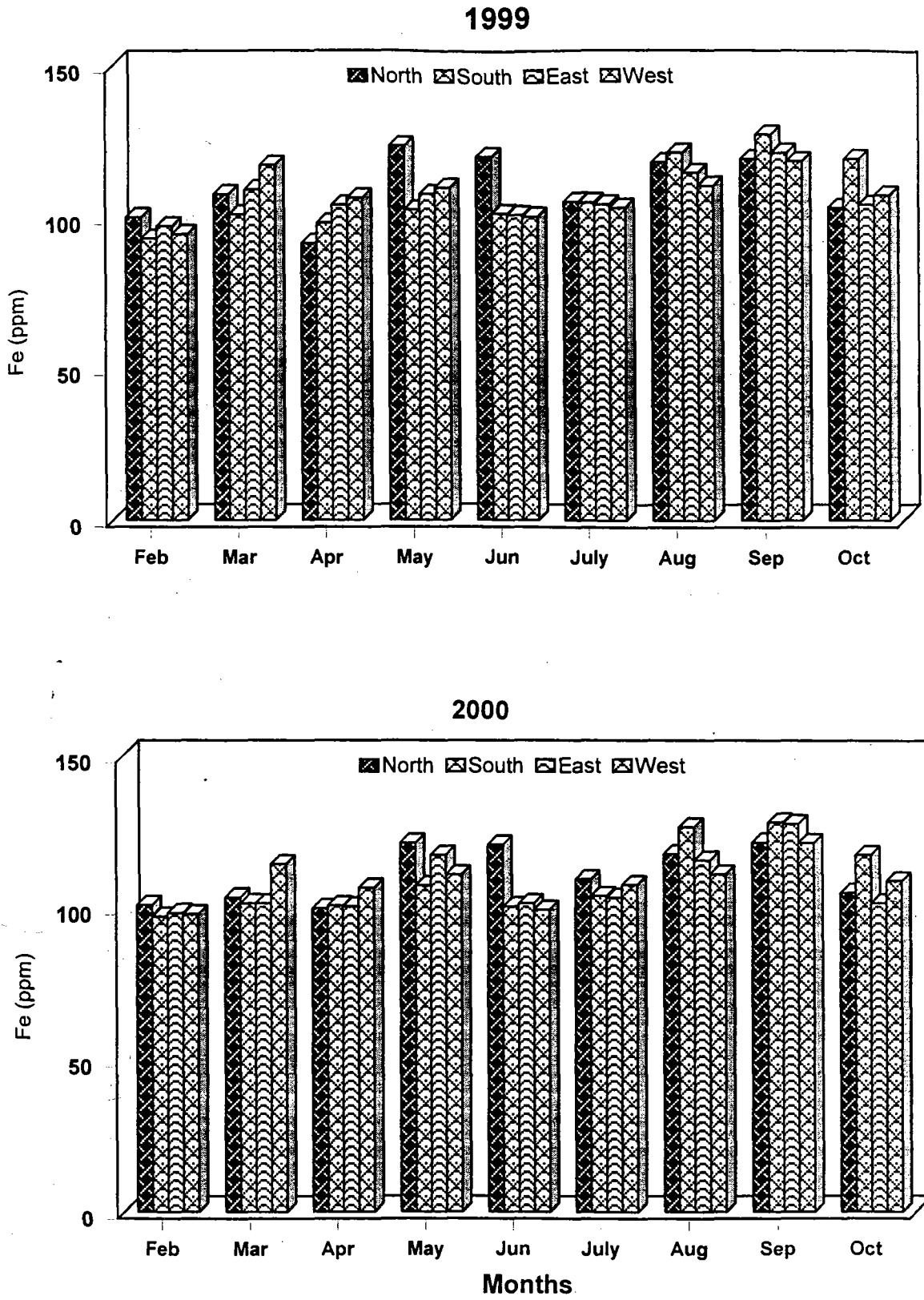


Fig. 7. Effect of aspect of tree on leaf Fe (ppm) content

during September and October on both the years (Tables No. 5.17; 5.18 and Fig.6).

During the stabilization period of August and September the Fe content has been consistently higher in case of T₃ in both the years. Though during first year the values of T₂ during stabilization period have been at par with T₃ and T₁, in second year during the same period that have recorded highest value (Tables No. 5.19; 5.20 and Fig.7).

4.3 Effect of varying doses of N on leaf nutrients status, yield and quality

4.3.1 Effect on leaf primary nutrients

The varying doses of N have shown a clear trend of leaf N status. Increase in the nitrogen dosage has increased the leaf N content. Obviously T₇ has recorded significantly higher N content in leaves followed by T₆ and T₅ whose values have been observed to be at par. Comparing the months all the treatments including control have recorded highest value during August, followed by September and then by July. However, during normal stabilization period of July to September except T₅, none of the other treatment values appears to be stabilizing in first year. During second year both T₅ and T₆ values appear to be stabilizing (Tables No. 6.1; 6.2 and Fig.8).

The effects of different doses of N on leaf P content also have been observed. In both the years T₇, T₆ and T₅ have recorded the highest mean P values. Amongst the treatments, during stabilization period, T₇ values have

Table 6.1. Effect of varying doses of N on leaf N (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	2.32	2.35	2.42	1.42	1.37	1.58	1.96	1.72	1.49	1.85
T ₂	2.27	2.32	2.48	1.46	1.39	1.57	1.97	1.88	1.53	1.87
T ₃	2.19	2.37	2.50	1.42	1.39	1.64	2.02	1.96	1.51	1.89
T ₄	2.22	2.36	2.57	1.64	1.59	2.12	2.48	2.21	2.06	2.14
T ₅	2.24	2.35	2.52	1.79	1.75	2.83	2.96	2.88	2.35	2.41
T ₆	2.19	2.47	2.61	1.81	1.79	2.84	2.94	2.85	2.36	2.43
T ₇	2.25	2.49	2.65	1.97	1.93	2.97	3.14	3.03	2.62	2.56
Mean	2.24	2.39	2.54	1.64	1.60	2.22	2.50	2.36	1.99	-

CD at 5% = Season (A) = 0.08; Treatment (B) = 0.07

Table 6.2. Effect of varying doses of N on leaf N (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	2.27	2.29	2.40	1.36	1.33	1.52	1.90	1.70	1.41	1.80
T ₂	2.24	2.30	2.42	1.46	1.39	1.55	1.92	1.73	1.40	1.82
T ₃	2.17	2.34	2.52	1.40	1.37	1.58	1.96	1.72	1.44	1.83
T ₄	2.19	2.36	2.58	1.65	1.60	2.17	2.52	2.27	2.18	2.17
T ₅	2.25	2.37	2.55	1.79	1.76	2.88	2.92	2.89	2.37	2.42
T ₆	2.21	2.49	2.61	1.82	1.79	2.85	2.96	2.85	2.39	2.44
T ₇	2.27	2.52	2.69	1.98	1.92	2.98	3.22	3.12	2.71	2.60
Mean	2.23	2.38	2.54	1.64	1.59	2.22	2.49	2.33	1.99	-

CD at 5% = Season (A) = 0.11; Treatment (B) = 0.10

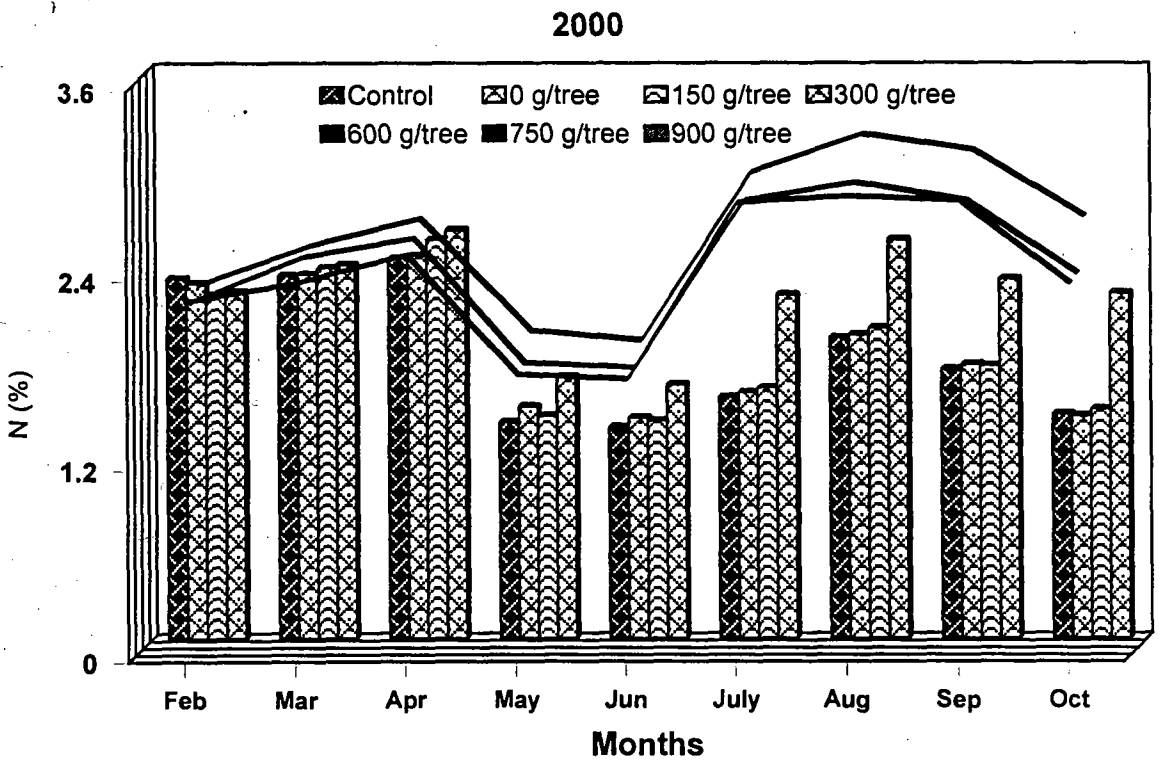
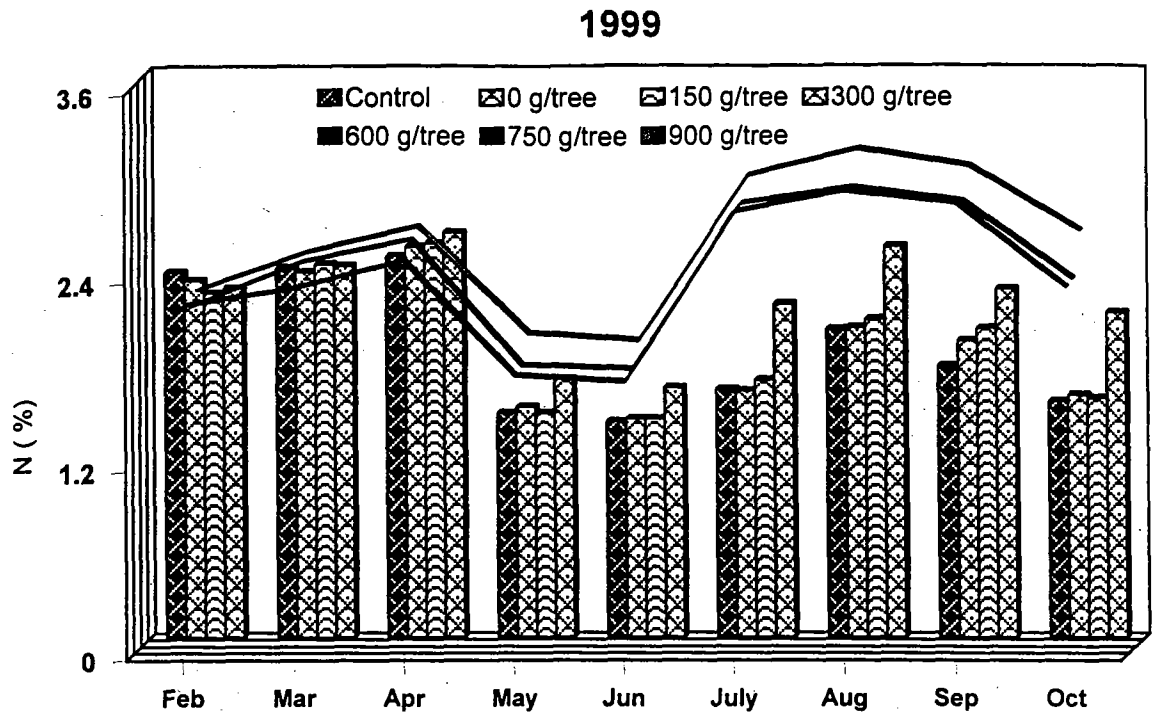


Fig. 8. Effect of varying doses of N on leaf N (%)

Table 6.3. Effect of varying doses of N on leaf P (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.17	0.17	0.18	0.13	0.12	0.18	0.16	0.19	0.21	0.17
T ₂	0.19	0.20	0.21	0.15	0.12	0.19	0.16	0.19	0.23	0.18
T ₃	0.16	0.20	0.19	0.16	0.13	0.20	0.18	0.21	0.25	0.19
T ₄	0.21	0.23	0.20	0.13	0.12	0.19	0.16	0.21	0.25	0.19
T ₅	0.19	0.28	0.25	0.17	0.15	0.18	0.18	0.22	0.27	0.21
T ₆	0.20	0.25	0.23	0.16	0.15	0.19	0.18	0.23	0.27	0.21
T ₇	0.21	0.24	0.23	0.16	0.14	0.23	0.20	0.28	0.31	0.22
Mean	0.19	0.22	0.21	0.15	0.13	0.19	0.17	0.22	0.26	-

CD at 5% = Season (A) = 0.01; Treatment (B) = 0.01

Table 6.4. Effect of varying doses of N on leaf P (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.16	0.17	0.18	0.14	0.12	0.18	0.17	0.19	0.21	0.17
T ₂	0.18	0.19	0.20	0.16	0.12	0.18	0.17	0.19	0.21	0.18
T ₃	0.17	0.21	0.22	0.16	0.13	0.21	0.18	0.21	0.26	0.19
T ₄	0.22	0.25	0.24	0.13	0.12	0.19	0.18	0.22	0.26	0.20
T ₅	0.20	0.28	0.26	0.17	0.16	0.19	0.19	0.24	0.27	0.22
T ₆	0.22	0.27	0.24	0.16	0.15	0.20	0.21	0.26	0.28	0.22
T ₇	0.25	0.27	0.26	0.16	0.15	0.22	0.24	0.28	0.32	0.24
Mean	0.20	0.23	0.23	0.15	0.14	0.20	0.19	0.23	0.26	-

CD at 5% = Season (A) = 0.12; Treatment (B) = 0.02

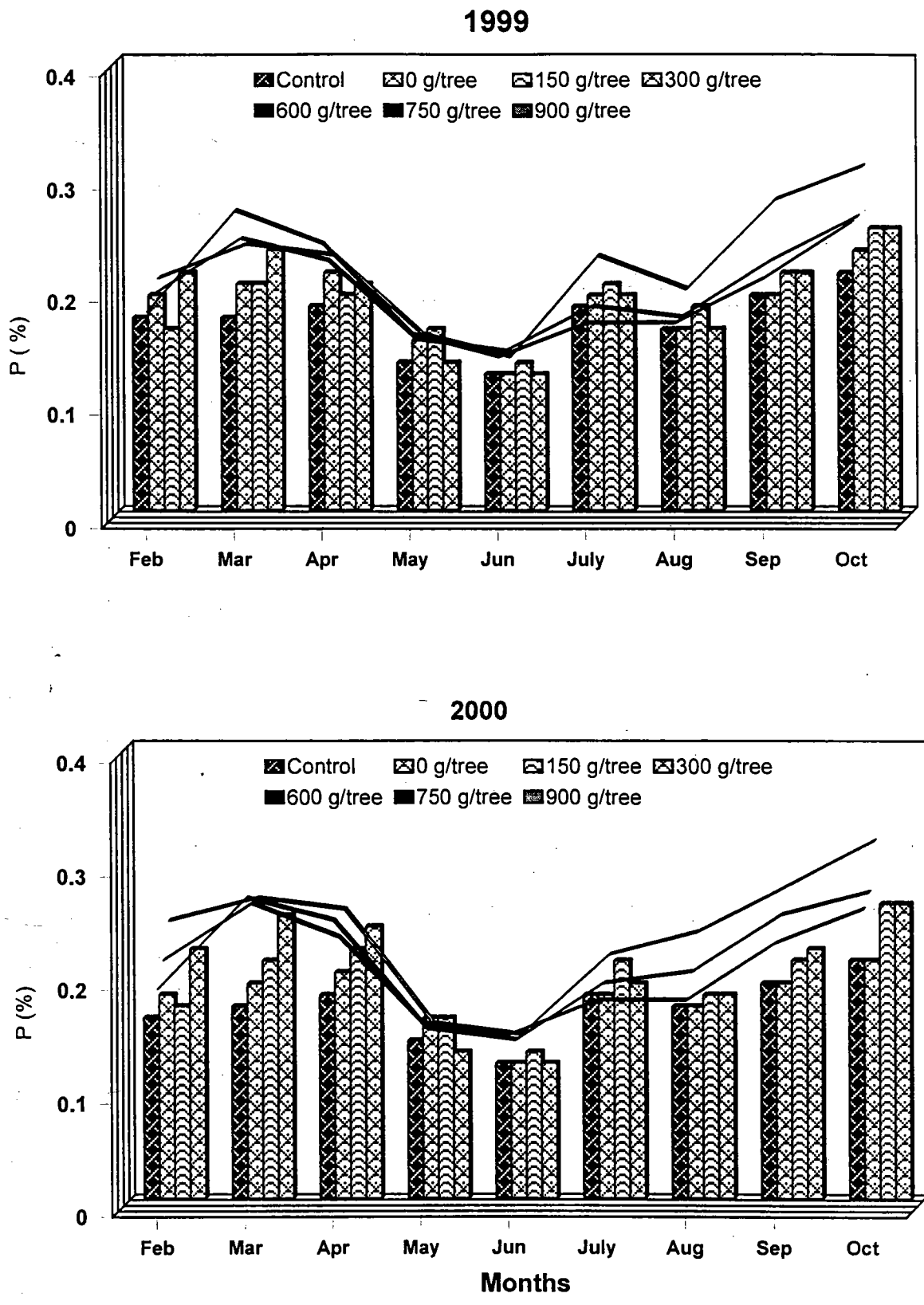


Fig. 9. Effect of varying doses of N on leaf P (%)

Table 6.5. Effect of varying doses of N on leaf K (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	1.42	1.57	1.61	1.34	1.17	1.42	1.60	1.62	1.66	1.49
T ₂	1.53	1.60	1.63	1.35	1.20	1.52	1.70	1.74	1.80	1.56
T ₃	1.52	1.59	1.64	1.35	1.31	1.55	1.71	1.79	1.81	1.59
T ₄	1.48	1.60	1.61	1.31	1.28	1.55	1.74	1.80	1.82	1.58
T ₅	1.48	1.65	1.67	1.35	1.31	1.60	1.65	1.78	1.83	1.59
T ₆	1.52	1.66	1.69	1.31	1.27	1.60	1.66	1.80	1.82	1.59
T ₇	1.46	1.52	1.56	1.33	1.30	1.58	1.68	1.78	1.85	1.56
Mean	1.49	1.60	1.63	1.33	1.26	1.55	1.68	1.78	1.80	-

CD at 5% = Season (A) = 0.07; Treatment (B) = 0.07

Table 6.6. Effect of varying doses of N on leaf K (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	1.40	1.50	1.62	1.30	1.14	1.41	1.62	1.63	1.69	1.48
T ₂	1.54	1.59	1.63	1.33	1.21	1.53	1.72	1.76	1.83	1.57
T ₃	1.60	1.62	1.67	1.39	1.30	1.58	1.81	1.83	1.88	1.63
T ₄	1.52	1.66	1.67	1.39	1.32	1.58	1.83	1.85	1.88	1.63
T ₅	1.50	1.60	1.66	1.40	1.35	1.61	1.85	1.86	1.90	1.64
T ₆	1.49	1.65	1.67	1.39	1.32	1.60	1.76	1.83	1.92	1.63
T ₇	1.50	1.66	1.69	1.38	1.26	1.62	1.68	1.88	1.90	1.62
Mean	1.50	1.61	1.65	1.37	1.27	1.56	1.75	1.87	1.86	-

CD at 5% = Season (A) = 0.08; Treatment (B) = 0.07

been found to be highest followed by T₆ and T₅ which have been found to be at par (Tables No. 6.3; 6.4 and Fig.9).

Effects of varying doses of N on leaf K content have been found to be very minimal which has been revealed by the fact that except control all other treatments mean K values are found to be at par. Even during the stabilization period the same trend has been observed. However, after T₅ the increase in N application has reduced the K content (Tables No. 6.5 and 6.6).

4.3.2 Effect on leaf secondary nutrients

The varying doses of N has given a confusing trend in case of leaf Ca content. Mean Ca values for all treatments including control have been found to be at par. However, during stabilization period T₃ in both the years has recorded the lowest values. Remaining all other treatments have been found to be at par at this period (Tables No. 6.7 and 6.8).

During the first year T₇ has proved superior for leaf Mg content followed by T₃, T₂, T₄ and T₆. However, during second year mean Mg values are found to be at par with T₇, T₃ and T₆ followed by T₅, T₂ and T₄. Here again T₇ has proved numerically superior. During the peak periods of February to April and August to October none of the treatments consistently and conclusively has proved superior (Tables No. 6.9 and 6.10).

Varying doses of N have no effect on leaf S content. All the treatments including control have produced almost similar values. However, the treatments have shown remarkable uniformity during stabilization period.

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Table 6.7. Effect of varying doses of N on leaf Ca (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	3.62	3.71	3.77	3.91	4.18	4.37	4.60	4.67	4.71	4.17
T ₂	3.70	3.72	3.75	3.99	4.17	4.36	4.43	4.52	4.68	4.15
T ₃	3.64	3.71	3.75	3.95	4.12	4.35	4.40	4.49	4.65	4.12
T ₄	3.63	3.74	3.81	3.94	4.15	4.33	4.53	4.61	4.72	4.16
T ₅	3.71	3.72	3.84	3.97	4.11	4.38	4.49	4.55	4.70	4.16
T ₆	3.61	3.73	3.80	3.91	4.14	4.31	4.47	4.57	4.69	4.14
T ₇	3.69	3.75	3.89	3.92	4.11	4.27	4.52	4.61	4.71	4.16
Mean	3.66	3.73	3.80	3.94	4.14	4.34	4.49	4.57	4.69	-

CD at 5% = Season (A) = 0.14; Treatment (B) = 0.12

Table 6.8. Effect of varying doses of N on leaf Ca (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	3.65	3.70	3.71	3.92	4.13	4.38	4.60	4.66	4.72	4.14
T ₂	3.58	3.61	3.71	3.90	4.15	4.34	4.58	4.59	4.63	4.12
T ₃	3.60	3.65	3.61	3.90	4.12	4.28	4.40	4.44	4.61	4.07
T ₄	3.60	3.63	3.60	3.84	4.10	4.25	4.43	4.48	4.52	4.05
T ₅	3.70	3.71	3.80	3.90	4.12	4.31	4.47	4.51	4.68	4.13
T ₆	3.66	3.72	3.79	3.89	4.09	4.36	4.42	4.55	4.62	4.12
T ₇	3.59	3.70	3.81	3.91	4.11	4.28	4.47	4.62	4.69	4.13
Mean	3.63	3.67	3.72	3.89	4.12	4.31	4.45	4.54	4.64	-

CD at 5% = Season (A) = 0.21; Treatment (B) = 0.18

Table 6.9. Effect of varying doses of N on leaf Mg (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.55	0.42	0.41	0.33	0.34	0.35	0.38	0.40	0.38	0.40
T ₂	0.52	0.44	0.40	0.35	0.34	0.38	0.42	0.45	0.41	0.41
T ₃	0.57	0.42	0.40	0.36	0.37	0.39	0.41	0.43	0.40	0.42
T ₄	0.53	0.45	0.42	0.36	0.34	0.38	0.43	0.44	0.40	0.42
T ₅	0.51	0.47	0.42	0.36	0.35	0.40	0.42	0.47	0.40	0.42
T ₆	0.54	0.46	0.44	0.39	0.39	0.40	0.42	0.42	0.39	0.43
T ₇	0.57	0.45	0.44	0.37	0.37	0.41	0.44	0.47	0.40	0.44
Mean	0.54	0.44	0.42	0.36	0.36	0.39	0.42	0.44	0.40	-

CD at 5% = Season (A) = 0.01; Treatment (B) = 0.01

Table 6.10. Effect of varying doses of N on leaf Mg (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.50	0.48	0.43	0.35	0.33	0.34	0.39	0.42	0.38	0.39
T ₂	0.55	0.49	0.45	0.36	0.37	0.39	0.42	0.45	0.42	0.43
T ₃	0.57	0.52	0.46	0.41	0.43	0.40	0.43	0.44	0.42	0.45
T ₄	0.59	0.47	0.41	0.35	0.33	0.39	0.43	0.44	0.40	0.42
T ₅	0.59	0.43	0.42	0.36	0.34	0.40	0.45	0.47	0.42	0.43
T ₆	0.60	0.45	0.42	0.36	0.34	0.42	0.45	0.46	0.42	0.44
T ₇	0.62	0.45	0.45	0.38	0.37	0.43	0.48	0.50	0.46	0.46
Mean	0.57	0.47	0.45	0.35	0.36	0.40	0.44	0.45	0.42	-

CD at 5% = Season (A) = 0.02; Treatment (B) = 0.02

Table 6.11. Effect of varying doses of N on leaf S (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.31	0.32	0.35	0.42	0.39	0.34	0.40	0.35	0.29	0.35
T ₂	0.19	0.28	0.36	0.39	0.37	0.35	0.39	0.36	0.33	0.34
T ₃	0.21	0.31	0.33	0.37	0.35	0.36	0.40	0.37	0.27	0.33
T ₄	0.17	0.27	0.35	0.38	0.33	0.35	0.40	0.38	0.31	0.33
T ₅	0.25	0.30	0.36	0.41	0.36	0.36	0.37	0.36	0.32	0.35
T ₆	0.27	0.29	0.36	0.40	0.37	0.38	0.38	0.35	0.31	0.35
T ₇	0.24	0.27	0.31	0.42	0.39	0.38	0.39	0.37	0.31	0.34
Mean	0.23	0.29	0.35	0.40	0.37	0.36	0.38	0.36	0.31	-

CD at 5% = Season (A) = 0.01; Treatment (B) = 0.06

Table 6.12. Effect of varying doses of N on leaf S (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.28	0.30	0.34	0.40	0.37	0.33	0.40	0.31	0.25	0.33
T ₂	0.20	0.24	0.33	0.37	0.30	0.28	0.41	0.33	0.32	0.31
T ₃	0.19	0.28	0.31	0.35	0.31	0.30	0.40	0.35	0.24	0.30
T ₄	0.15	0.21	0.35	0.39	0.35	0.37	0.42	0.38	0.30	0.32
T ₅	0.24	0.29	0.37	0.42	0.35	0.36	0.40	0.39	0.32	0.35
T ₆	0.28	0.29	0.35	0.37	0.35	0.39	0.41	0.40	0.38	0.36
T ₇	0.27	0.29	0.37	0.39	0.37	0.38	0.42	0.39	0.37	0.36
Mean	0.23	0.27	0.35	0.38	0.34	0.34	0.41	0.36	0.31	-

CD at 5% = Season (A) = 0.02; Treatment (B) = 0.08

Amongst treatments T_5 has produced consistent results during stabilization period on both the years of study. Though stabilization period has occurred from June to September in first year, for T_5 it has occurred in two phases in second year, one during June and July and another one during August and September (Tables No. 6.11 and 6.12).

4.3.3 Effect on leaf micronutrients

The mean values and values during stabilization period have indicated that every incremental application has increased the leaf Mn values from T_1 to T_7 . The mean values of Mn have revealed that T_7 , T_6 and T_5 are at par. However, during stabilization period of July to September only T_6 and T_7 have shown statistically similar values. T_5 has been found to be at par with T_6 and T_7 only during July and August. The real stabilization of values has occurred in T_5 and T_6 on both the years. The stabilization has occurred only during second year for T_7 (Tables No. 6.13; 6.14 and Fig.10).

The mean Zn values and the values at stabilization period have shown that N application has increased the Zn in leaves from T_1 to T_7 . In both the years of study the mean Zn values have been found to be at par from T_3 to T_7 . However, only T_6 and T_7 have shown consistently higher values during the stabilization period of May to October. Amongst treatments, T_7 has shown higher mean values during peak period i.e. June and July (Tables No. 6.15 and 6.16).

Table 6.13. Effect of varying doses of N on leaf Mn (ppm) content of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	25.1	31.2	26.4	41.3	35.6	37.8	49.3	50.2	32.1	37.67
T ₂	23.0	31.4	25.4	43.6	37.2	47.9	49.6	51.2	32.6	37.99
T ₃	23.6	31.8	26.3	44.2	37.3	49.2	49.8	51.1	31.1	38.27
T ₄	25.2	30.1	27.4	45.2	39.6	51.4	55.3	50.4	35.7	40.70
T ₅	24.4	30.4	28.3	49.2	40.2	57.1	59.6	50.3	35.6	41.68
T ₆	20.9	31.6	30.3	51.6	47.3	59.4	61.3	56.4	41.2	44.39
T ₇	23.2	33.6	31.2	51.6	49.2	57.4	61.8	56.6	44.6	45.69
Mean	24.41	31.44	27.90	46.67	40.91	53.17	55.24	52.31	36.13	-

CD at 5% = Season (A) = 3.12; Treatment (B) = 4.08

Table 6.14. Effect of varying doses of N on leaf Mn (ppm) content of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	23.2	27.3	21.2	40.1	31.7	39.2	40.2	43.7	35.1	33.52
T ₂	22.7	27.7	22.1	40.7	32.9	40.3	42.1	45.7	33.4	34.18
T ₃	23.7	29.6	25.4	43.1	35.2	42.3	43.7	48.4	33.7	36.12
T ₄	25.4	30.2	26.3	44.2	40.2	49.8	50.9	49.7	35.1	39.09
T ₅	25.9	31.2	30.4	50.1	42.4	55.9	60.3	50.4	35.8	42.49
T ₆	27.1	33.3	31.4	53.2	47.4	56.7	60.4	51.7	42.7	44.98
T ₇	25.2	34.2	32.1	53.0	49.7	59.8	61.2	55.3	43.2	45.97
Mean	24.74	30.50	26.99	46.34	39.93	49.14	52.26	49.27	37.00	-

CD at 5% = Season (A) = 4.41; Treatment (B) = 3.94

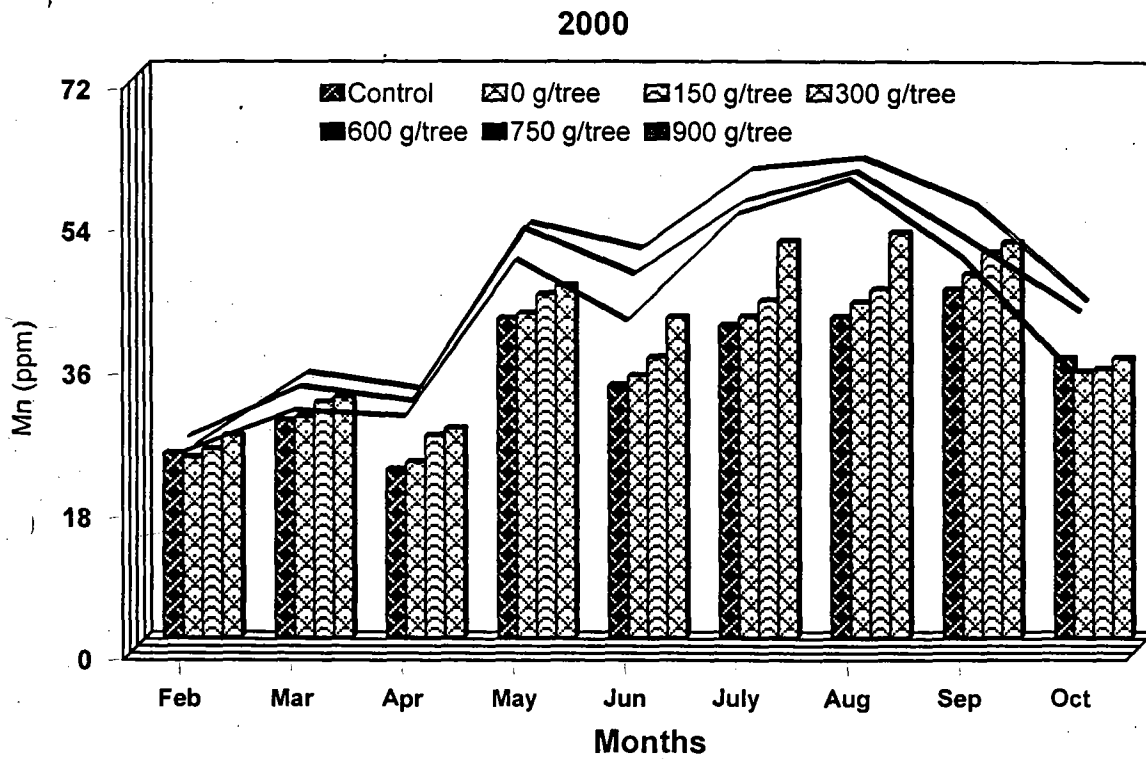
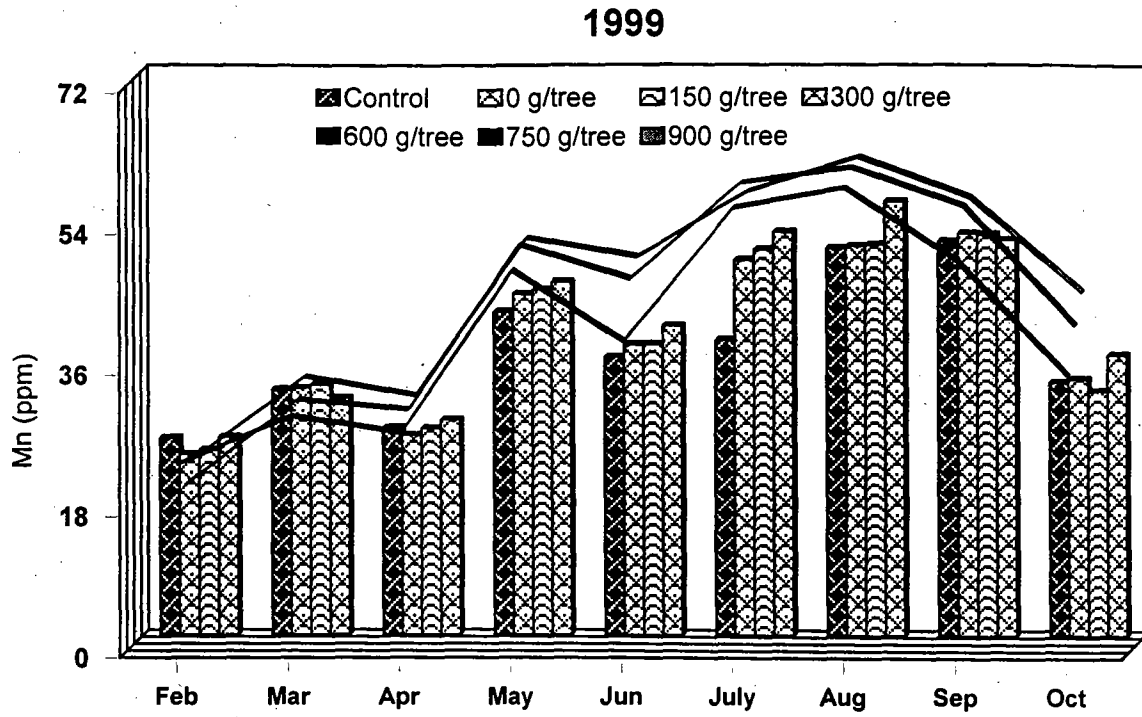


Fig. 10. Effect of varying doses of N on leaf Mn (ppm) content

Table 6.15. Effect of varying doses of N on leaf Zn (ppm) content of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	12.1	12.5	12.6	12.9	13.6	13.6	13.5	13.5	13.3	13.07
T ₂	10.9	11.8	12.3	12.9	13.7	13.7	13.4	13.4	13.2	12.81
T ₃	12.3	12.6	12.7	13.1	13.9	13.9	13.7	13.5	13.0	13.19
T ₄	12.0	12.5	12.8	13.4	14.0	13.9	13.6	13.5	13.3	13.22
T ₅	11.6	12.6	12.8	13.8	14.2	14.1	13.9	13.8	13.5	13.57
T ₆	11.8	12.6	12.9	13.9	14.6	14.3	14.1	13.9	13.6	13.52
T ₇	11.4	12.8	13.1	14.2	15.2	15.0	14.6	13.9	13.6	13.74
Mean	11.73	12.49	12.14	13.46	14.17	14.07	13.81	13.64	13.36	-

CD at 5% = Season (A) = 0.89; Treatment (B) = 0.61

Table 6.16. Effect of varying doses of N on leaf Zn (ppm) content of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	12.0	12.3	12.4	12.5	12.8	12.4	13.1	13.4	13.0	12.66
T ₂	11.8	12.0	12.3	12.6	12.9	13.5	13.5	13.6	13.1	12.71
T ₃	12.8	12.9	12.9	13.2	13.5	13.3	13.3	13.2	13.0	13.11
T ₄	12.5	12.7	12.9	13.3	13.8	13.8	13.8	13.6	13.2	13.23
T ₅	12.0	12.5	12.9	13.5	14.2	14.4	14.4	13.9	13.7	13.46
T ₆	12.8	12.9	13.1	13.8	14.6	14.5	14.5	14.2	13.9	13.78
T ₇	11.9	12.8	13.3	14.4	15.6	14.6	14.6	14.1	13.9	13.98
Mean	12.26	12.59	12.83	13.33	13.91	13.89	13.89	13.71	13.40	-

CD at 5% = Season (A) = 0.69; Treatment (B) = 0.91

Table 6.17 Effect of varying doses of N on leaf Cu (ppm) content of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	7.9	8.2	8.4	8.6	8.7	8.7	8.9	11.3	9.3	8.89
T ₂	8.2	8.4	8.5	8.5	8.6	8.7	8.9	11.2	9.1	8.90
T ₃	7.4	8.2	8.4	8.5	8.7	8.7	9.3	11.4	9.3	8.88
T ₄	7.6	8.3	8.4	8.5	8.6	8.7	9.3	11.7	9.5	8.96
T ₅	8.1	8.3	8.4	8.6	8.7	8.8	9.5	11.7	9.6	9.08
T ₆	8.3	8.5	8.6	8.8	8.9	8.9	9.7	11.8	9.5	9.22
T ₇	7.9	8.3	8.6	8.9	9.0	9.1	9.8	11.8	9.6	9.22
Mean	7.91	8.31	8.47	8.63	8.74	8.80	9.34	11.56	9.41	-

CD at 5% = Season (A) = 0.45; Treatment (B) = 0.40

Table 6.18. Effect of varying doses of N on leaf Cu (ppm) content of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	8.0	8.2	8.3	8.5	8.7	8.8	8.9	10.9	9.1	8.82
T ₂	8.5	8.4	8.4	8.4	8.5	8.6	8.8	9.8	9.2	8.73
T ₃	8.0	8.4	8.5	8.6	8.7	8.5	9.1	10.9	9.2	8.88
T ₄	7.9	8.0	8.6	8.8	8.9	8.9	9.3	11.2	9.5	9.01
T ₅	8.2	8.3	8.5	8.6	8.8	8.9	9.7	11.7	9.6	9.14
T ₆	8.5	8.6	8.7	8.9	9.1	9.2	9.6	11.5	9.5	9.29
T ₇	7.8	8.8	8.9	9.0	9.2	9.5	9.8	11.8	9.5	9.37
Mean	8.12	8.39	8.56	8.69	8.84	8.91	9.31	11.11	9.36	-

CD at 5% = Season (A) = 0.4.; Treatment (B) = 0.38

Table 6.19. Effect of varying doses of N on leaf Fe (ppm) content of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	110.4	120.3	88.3	120.4	125.3	120.3	124.8	129.2	131.3	118.26
T ₂	98.7	118.2	86.3	120.7	124.3	124.2	124.7	129.6	133.4	117.18
T ₃	97.9	120.4	89.7	126.4	129.3	122.4	129.4	139.8	143.2	119.83
T ₄	107.8	122.4	88.6	122.4	123.5	120.6	128.4	137.3	140.3	121.98
T ₅	109.2	125.2	90.4	128.2	129.8	125.2	129.9	139.8	144.3	124.54
T ₆	110.2	122.1	80.3	117.6	118.1	109.3	114.7	128.9	131.4	116.66
T ₇	99.8	117.4	81.2	117.4	119.2	104.5	116.2	125.3	135.2	112.89
Mean	104.86	120.86	86.40	121.87	124.21	117.64	124.01	133.40	135.60	-

CD at 5% = Season (A) = 5.32; Treatment (B) = 4.81

Table 6.20. Effect of varying doses of N on leaf Fe (ppm) content of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	97.7	103.2	79.9	110.2	117.1	109.8	109.8	113.2	115.4	105.49
T ₂	92.4	105.7	80.2	116.1	118.9	120.4	122.1	124.5	126.3	111.84
T ₃	95.3	105.9	82.1	120.4	127.3	119.5	120.7	131.8	135.9	115.43
T ₄	100.3	117.3	88.6	125.4	126.8	120.2	125.9	134.4	140.7	119.96
T ₅	109.2	123.4	90.4	125.8	128.1	122.7	129.1	135.1	142.1	122.88
T ₆	103.2	117.4	85.4	120.8	122.4	109.8	111.2	125.3	132.8	114.26
T ₇	95.4	112.2	80.8	115.4	119.8	102.2	104.8	120.9	130.4	109.10
Mean	98.07	112.16	83.91	119.16	122.91	114.94	117.67	126.46	131.94	-

CD at 5% = Season (A) = 7.80; Treatment (B) = 5.12

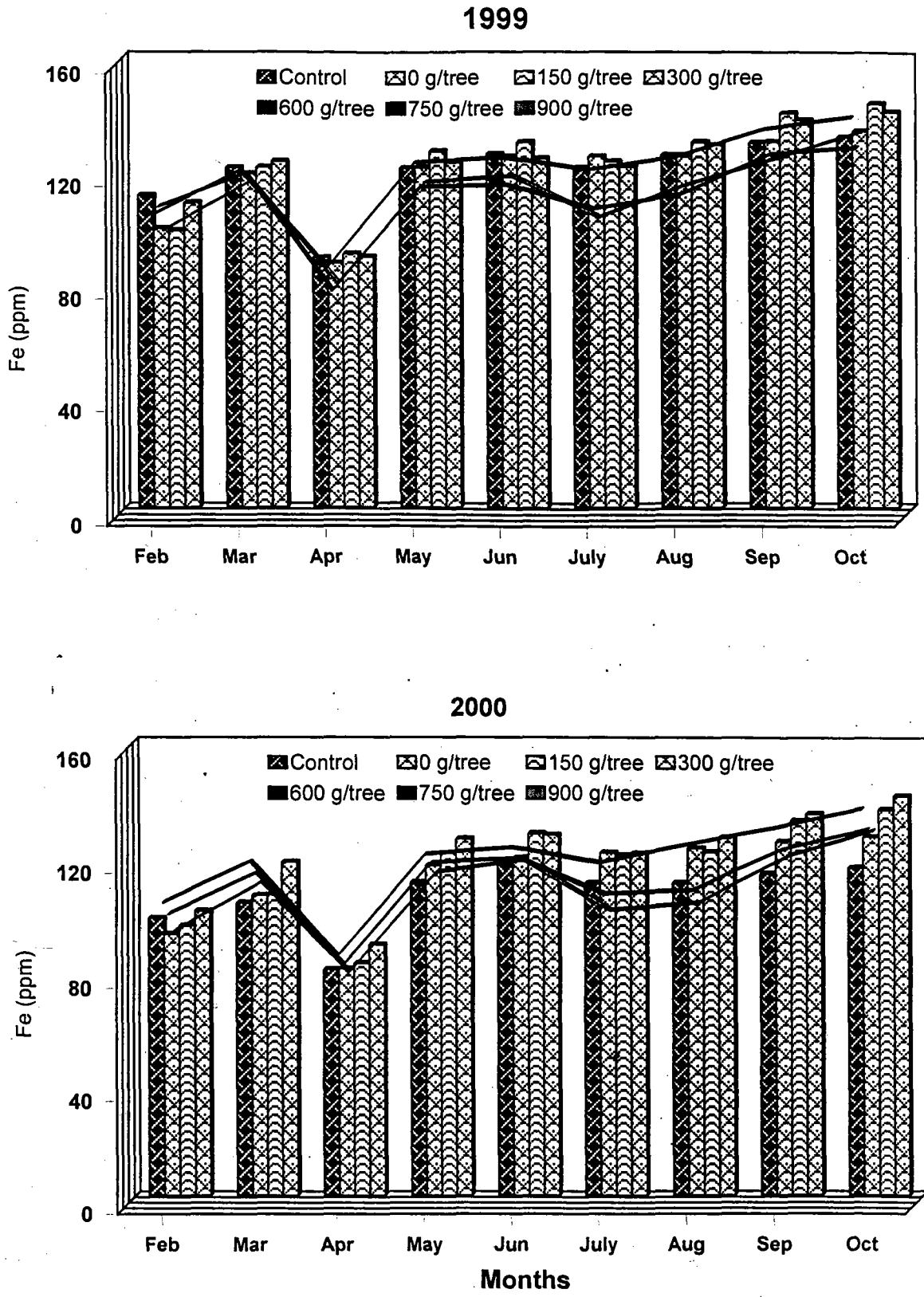


Fig. 11. Effect of varying doses of N on leaf Fe (ppm) content

The varying dose of N have not affected the leaf Cu content much. Mean Cu values have been found to be at par in all the treatments. However, during peak period of September, T₃ to T₇ have been found to be higher and at par during first year and only T₅ to T₇ have been found to be higher and at par during second year. Mean Cu values have increased from T₁ to T₇ (Tables No. 6.17 and 6.18).

Mean Fe content of leaves have revealed that only T₄ and T₅ are superior than rest of the treatments. During stabilization period of September and October also same results have been observed. The mean Fe values have increased from T₁ till T₅ and then they have decreased (Tables No. 6.19; 6.20 and Fig.11).

4.3.4 Effect on yield and quality

Individual fruit weight has increased from T₁ to T₇. Amongst the treatment T₇ has proved numerically superior. However, statistically it has been found to be at par with T₆ and T₅. T₁ has produced lowest individual fruit weight. However, T₂ has been found to be at par with T₁.

Addition of N has increased the number of fruits/ tree. Highest number of fruits/tree has been produced at T₇ level. However, T₆ and T₅ have also been found to be at par with T₇.

Highest amount of juice percentage has been produced in T₆. Further increase in N beyond T₆ has reduced the juice percentage. However, T₅, T₆ and T₇ have been found to be statistically at par.

Table 6.21. Effect of varying doses of N on yield and quality parameters of Kinnow during 1999

Treatments	Individual fruit wt. (g)	No. of fruits/tree	Juice (%)	TSS (%)	Titration acidity (%)
T ₁	121.2	35.2	41.02	8.82	0.89
T ₂	127.5	36.4	41.07	9.02	0.88
T ₃	133.2	35.3	43.20	9.15	0.96
T ₄	148.4	37.1	46.25	9.65	1.08
T ₅	160.2	39.2	49.25	10.40	1.02
T ₆	161.3	39.8	49.50	10.75	1.02
T ₇	168.4	41.0	47.05	9.95	0.92
CD at 5%	8.55	1.92	2.33	0.66	0.03

Table 6.22. Effect of varying doses of N on yield and quality parameters of Kinnow during 2000

Treatments	Individual fruit wt. (g)	No. of fruits/tree	Juice (%)	TSS (%)	Titration acidity (%)
T ₁	124.3	33.7	40.47	9.02	0.77
T ₂	125.8	38.2	42.21	9.08	0.81
T ₃	137.4	42.1	45.72	9.32	0.93
T ₄	150.6	45.2	46.32	10.30	1.02
T ₅	166.1	53.4	48.11	10.72	0.95
T ₆	170.2	54.8	49.24	10.96	0.95
T ₇	172.3	55.4	49.06	10.12	10.92
CD at 5%	9.73	2.23	1.58	0.37	0.03

Fruit TSS percentage has shown an increasing trend for every addition of N till T₆ level. However, beyond T₆ it has shown a decreasing trend. T₆ and T₅ have been found to be at par and they have proved superior to rest of the treatments.

Highest titrable acidity percentage has been found at T₄ level. From T₅ onwards it has shown a decreasing trend. During first year T₅ and T₆ have produced next highest amount of acidity. However, during second year T₅, T₆ and T₇ have been found to be at par.

4.4 Effect of varying doses of P on leaf nutrient content, yield and quality

4.4.1 Effect on leaf primary nutrients

The different doses of P have not shown distinct effect on leaf nitrogen. Mean N values have shown that all the treatments except T₁ are superior and at par. However, during the stabilization period of July to September only T₃, T₄ and T₅ are found superior and found to be at par (Tables No. 7.1 and 7.2).

Increasing dose of P has a marked effect on leaf P content. The leaf P content has increased from T₁ to T₅. In which T₄ and T₅ have been found to be superior than the rest of the treatments. Though the mean value of P content in leaves have revealed that T₄ and T₅ are at par, during stabilization period of July and August T₅ was found to be superior. However, during the peak period i.e. September and October, T₄ and T₅ have been found to be superior and at par (Tables No. 7.3; 7.4 and Fig.12).

Table 7.1. Effect of varying doses of P on leaf N (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	2.32	2.41	2.45	1.37	1.39	1.49	1.88	1.72	1.50	1.837
T ₂	2.46	2.48	2.55	1.69	1.55	2.68	2.73	2.70	2.65	2.388
T ₃	2.31	2.43	2.58	1.65	1.57	2.72	2.81	2.75	2.68	2.389
T ₄	2.17	2.36	2.56	1.81	1.78	2.86	2.96	2.83	2.71	2.449
T ₅	2.22	2.37	2.51	1.82	1.80	2.83	2.92	2.84	2.67	2.443
Mean	2.296	2.410	2.530	1.668	1.618	2.516	2.660	2.568	2.444	-

CD at 5% = Season (A) = 0.101; Treatment (B) = 0.153

Table 7.2. Effect of varying doses of P on leaf N (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T	2.21	2.39	2.41	1.26	1.31	1.39	1.80	1.72	1.62	1.790
T ₂	2.38	2.46	2.52	1.68	1.58	2.62	2.78	2.68	2.62	2.369
T ₃	2.36	2.45	2.58	1.70	1.63	2.75	2.80	2.75	2.70	2.413
T ₄	2.32	2.39	2.94	1.88	1.81	2.85	2.92	2.86	2.73	2.482
T ₅	2.35	2.39	2.60	1.85	1.80	2.81	2.90	2.82	2.70	2.469
Mean	2.324	2.416	2.538	1.674	1.626	2.484	2.640	2.566	2.474	

CD at 5% = Season (A) = 0.162; Treatment (B) = 0.121

Table 7.3. Effect of varying doses of P on leaf P (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.15	0.17	0.18	0.16	0.12	0.18	0.17	0.19	0.22	0.171
T ₂	0.13	0.16	0.16	0.15	0.13	0.18	0.17	0.20	0.22	0.167
T ₃	0.17	0.18	0.17	0.15	0.12	0.19	0.19	0.23	0.24	0.181
T ₄	0.16	0.22	0.20	0.16	0.15	0.20	0.20	0.24	0.26	0.199
T ₅	0.19	0.22	0.21	0.15	0.13	0.22	0.23	0.25	0.27	0.208
Mean	0.160	0.190	0.184	0.154	0.130	0.194	0.192	0.222	0.242	-

CD at 5% = Season (A) = 0.015; Treatment (B) = 0.011

Table 7.4. Effect of varying doses of P on leaf P (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.16	0.18	0.18	0.16	0.13	0.18	0.17	0.19	0.21	0.173
T ₂	0.15	0.18	0.19	0.15	0.13	0.18	0.17	0.19	0.21	0.172
T ₃	0.17	0.18	0.16	0.15	0.14	0.19	0.20	0.23	0.25	0.186
T ₄	0.19	0.24	0.22	0.16	0.15	0.21	0.21	0.25	0.26	0.210
T ₅	0.20	0.25	0.23	0.19	0.17	0.24	0.23	0.27	0.32	0.233
Mean	0.174	0.206	0.196	0.162	0.144	0.200	0.196	0.226	0.250	-

CD at 5% = Season (A) = 0.014; Treatment (B) = 0.023

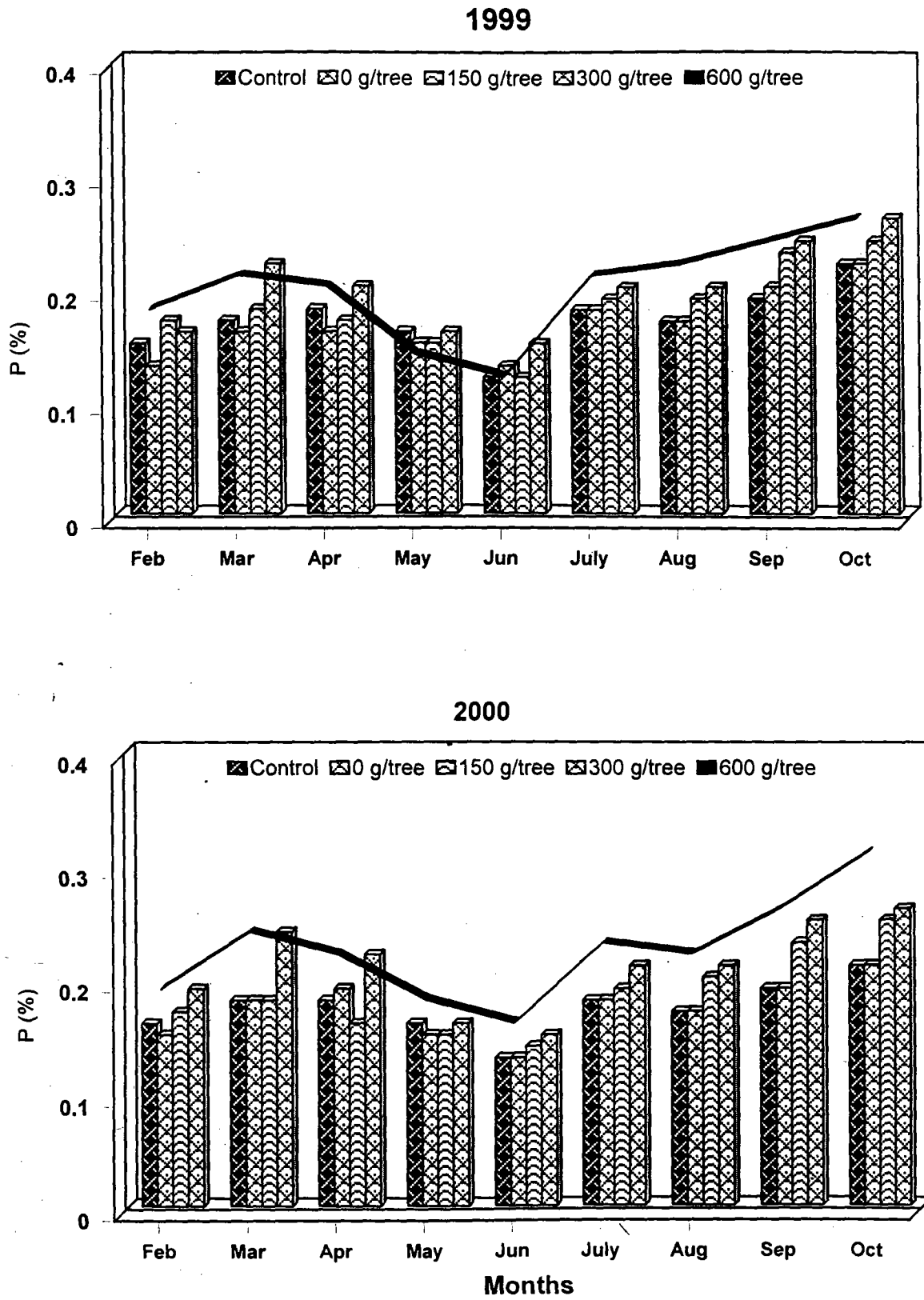


Fig. 12. Effect of varying doses of P on leaf P (%)

Table 7.5. Effect of varying doses of P on leaf K (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	1.48	1.58	1.64	1.35	1.17	1.44	1.68	1.69	1.72	1.528
T ₂	1.51	1.52	1.53	1.41	1.26	1.64	1.70	1.78	1.79	1.571
T ₃	1.54	1.61	1.64	1.34	1.27	1.64	1.69	1.75	1.79	1.586
T ₄	1.46	1.50	1.61	1.37	1.30	1.62	1.76	1.78	1.81	1.579
T ₅	1.53	1.57	1.60	1.35	1.32	1.60	1.68	1.78	1.80	1.581
Mean	1.504	1.556	1.604	1.364	1.264	1.588	1.702	1.756	1.782	-

CD at 5% = Season (A) = 0.093; Treatment (B) = 0.069

Table 7.6. Effect of varying doses of P on leaf K (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	1.46	1.52	1.55	1.32	1.18	1.38	1.60	1.65	1.68	1.482
T ₂	1.52	1.55	1.58	1.42	1.26	1.65	1.72	1.78	1.80	1.587
T ₃	1.56	1.60	1.64	1.38	1.30	1.67	1.75	1.75	1.76	1.601
T ₄	1.52	1.57	1.65	1.38	1.30	1.65	1.78	1.79	1.81	1.606
T ₅	1.55	1.59	1.62	1.37	1.34	1.62	1.69	1.80	1.79	1.597
Mean	1.522	1.566	1.608	1.374	1.276	1.594	1.708	1.754	1.768	-

CD at 5% = Season (A) = 0.098; Treatment (B) = 0.073

Increasing dose of P has not produced any traceable increase in leaf K content. Except T₁, all other treatments have been found to be statistically at par both in their mean values and during stabilization period of August to October. During stabilization period T₁ was found to be inferior to rest of the treatments. However, during first year of study the mean K value of T₁ has been found to be at par with other treatments (Tables No. 7.5 and 7.6).

4.4.2 Effect on leaf secondary nutrients

Mean leaf Ca values have not been affected by increase in P fertilizers. Even during stabilization period of August to September. The leaf contents have been found to be at par for all the treatments except T₁. In T₁ during August on both the years of study the leaf Ca content has been found to be at numerically highest level. However, statistically it has been found to be at par with T₃ and T₄ in first year of study and with T₃, T₄ and T₅ in second year of study (Tables No. 7.7 and 7.8).

Leaf Mg contents have been found to be increasing with increasing level of P application. The Mean Mg values have attained a peak in T₄ then on it has started decreasing. However, T₃, T₄ and T₅ have been found to be statistically at par. During the stabilization period of August and September also T₃, T₄ and T₅ have been found to be at par (Tables No. 7.9 and 7.10).

Mean leaf S content has not been affected by increasing P fertilizer. All the treatments have been found to be at par. Even during stabilization period of

Table 7.7. Effect of varying doses of P on leaf Ca (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	3.63	3.71	3.77	3.91	4.18	4.37	4.60	4.67	4.71	4.172
T ₂	3.69	3.75	3.81	3.98	4.28	4.39	4.42	4.51	4.73	4.173
T ₃	3.72	3.79	3.80	3.95	4.21	4.41	4.51	4.53	4.77	4.188
T ₄	3.63	3.69	3.84	3.97	4.16	4.38	4.48	4.57	4.69	4.157
T ₅	3.65	3.73	3.76	3.99	4.17	4.36	4.42	4.61	4.71	4.156
Mean	3.664	3.734	3.796	3.96	4.200	4.382	4.486	4.578	4.722	-

CD at 5% = Season (A) = 0.195; Treatment (B) = 0.156

Table 7.8. Effect of varying doses of P on leaf Ca (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	3.60	3.69	3.74	3.85	4.01	4.24	4.60	4.64	4.68	4.116
T ₂	3.71	3.77	3.80	3.95	4.21	4.38	4.41	4.50	4.78	4.168
T ₃	3.75	3.80	3.82	3.92	4.18	4.40	4.53	4.55	4.70	4.183
T ₄	3.68	3.71	3.85	3.97	4.11	4.32	4.51	4.59	4.71	4.161
T ₅	3.70	3.75	3.77	3.95	4.19	4.37	4.53	4.62	4.75	4.181
Mean	3.688	3.744	3.796	3.928	4.140	4.342	4.516	4.580	4.724	-

CD at 5% = Season (A) = 0.222; Treatment (B) = 0.166

Table 7.9. Effect of varying doses of P on leaf Mg (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.55	0.42	0.41	0.33	0.34	0.35	0.38	0.40	0.38	0.396
T ₂	0.58	0.45	0.40	0.34	0.35	0.37	0.41	0.44	0.40	0.414
T ₃	0.59	0.49	0.43	0.39	0.35	0.40	0.42	0.44	0.41	0.436
T ₄	0.51	0.43	0.40	0.35	0.35	0.38	0.42	0.44	0.41	0.436
T ₅	0.55	0.46	0.42	0.39	0.35	0.36	0.39	0.40	0.39	0.416
Mean	0.556	0.450	0.412	0.360	0.348	0.372	0.404	0.422	0.396	-

CD at 5% = Season (A) = 0.026; Treatment (B) = 0.019

Table 7.10. Effect of varying doses of P on leaf Mg (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.59	0.47	0.41	0.30	0.31	0.36	0.37	0.42	0.37	0.400
T ₂	0.55	0.42	0.40	0.39	0.35	0.35	0.39	0.39	0.37	0.401
T ₃	0.54	0.42	0.40	0.34	0.36	0.78	0.42	0.44	0.40	0.411
T ₄	0.53	0.45	0.43	0.36	0.34	0.39	0.40	0.42	0.41	0.414
T ₅	0.57	0.47	0.42	0.33	0.32	0.35	0.41	0.42	0.40	0.410
Mean	0.556	0.446	0.412	0.344	0.336	0.366	0.398	0.418	0.390	-

CD at 5% = Season (A) = 0.020; Treatment (B) = 0.011

Table 7.11. Effect of varying doses of P on leaf S (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.31	0.32	0.35	0.42	0.36	0.34	0.40	0.35	0.29	0.349
T ₂	0.30	0.31	0.39	0.40	0.37	0.34	0.41	0.37	0.31	0.356
T ₃	0.25	0.27	0.36	0.42	0.36	0.34	0.39	0.35	0.34	0.342
T ₄	0.26	0.29	0.36	0.42	0.35	0.35	0.39	0.35	0.31	0.342
T ₅	0.32	0.34	0.38	0.40	0.36	0.36	0.38	0.37	0.30	0.357
Mean	0.288	0.302	0.368	0.412	0.360	0.346	0.394	0.358	0.310	-

CD at 5% = Season (A) = 0.020; Treatment (B) = 0.015

Table 7.12. Effect of varying doses of P on leaf S (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.30	0.30	0.32	0.39	0.37	0.32	0.40	0.36	0.30	0.340
T ₂	0.30	0.31	0.35	0.40	0.37	0.35	0.40	0.35	0.31	0.349
T ₃	0.28	0.29	0.36	0.41	0.35	0.35	0.41	0.35	0.31	0.346
T ₄	0.26	0.28	0.37	0.40	0.35	0.34	0.49	0.36	0.32	0.341
T ₅	0.30	0.32	0.38	0.40	0.35	0.32	0.36	0.38	0.30	0.346
Mean	0.288	0.300	0.356	0.400	0.358	0.336	0.392	0.360	0.308	-

CD at 5% = Season (A) = 0.023; Treatment (B) = 0.017

June and July all the treatments have been found to be at par (Tables No. 7.11 and 7.12).

4.4.3 Effect on leaf micronutrients

Increasing amount of P has been found to increase leaf Mn content. T₅ with highest amount of P application has been found to be superior in mean leaf Mn content. However, T₄ has been found to be statistically at par with T₅. In second year of study the stabilization period of July and August, T₅ has been found to be superior. At the same period in first year of study, only in July, T₅ has been found to be superior than rest of the treatments. During the same period, though T₃ has produced higher value in August in first year and in July and August as that of T₄ (Tables No. 7.13 and 7.14)

The mean leaf Zn values of all the treatments have been found to be at par. However increasing P application has been found to increase leaf Zn value upto the level of T₄, further increase in application of P at T₅ level has been found to decrease. This trend has been found to be true even during stabilization period of June to September (Tables No. 7.15 and 7.16).

The increase in P application has not affected the mean leaf Cu content. All the treatments except T₁ have been found to be statistically at par. T₁ too has been found to be at par with other treatments during first year of study. However, during peaking period i.e. in September. The leaf Cu content has been found to be decreasing after the level of T₄ to the addition of P (Tables No. 7.17 and 7.18).

Table 7.13. Effect of varying doses of P on leaf Mn (ppm) content of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	25.1	31.2	26.4	41.3	35.6	47.8	49.3	50.2	32.1	37.67
T ₂	22.3	30.6	25.3	40.3	33.9	45.1	53.2	49.4	37.1	37.47
T ₃	27.1	32.7	25.6	39.7	36.2	49.2	57.3	52.9	32.6	39.26
T ₄	23.3	29.9	27.3	48.9	42.6	53.3	56.9	51.6	35.6	41.04
T ₅	23.2	35.4	28.2	49.9	41.2	60.2	47.2	55.4	36.9	41.96
Mean	24.20	31.96	26.56	44.02	37.90	51.12	52.78	51.90	34.86	-

CD at 5% = Season (A) = 2.73; Treatment (B) = 2.04

Table 7.14. Effect of varying doses of P on leaf Mn (ppm) content of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	23.3	31.0	25.3	41.6	33.9	47.6	48.3	52.3	32.9	37.36
T ₂	25.7	30.7	25.2	39.6	35.1	61.2	57.4	49.9	35.6	40.04
T ₃	28.2	32.1	30.6	39.6	36.2	57.2	57.6	50.4	32.7	40.51
T ₄	24.2	32.1	28.2	50.2	41.5	52.7	57.6	52.9	35.2	41.12
T ₅	23.6	35.2	28.7	49.8	41.2	60.2	61.2	49.7	35.2	42.76
Mean	25.00	32.22	27.60	44.16	37.58	55.78	56.42	51.04	34.32	-

CD at 5% = Season (A) = 2.28; Treatment (B) = 1.70

Table 7.15. Effect of varying doses of P on leaf Zn (ppm) content of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	12.1	12.5	12.6	12.9	13.6	13.6	13.5	13.5	13.3	13.07
T ₂	10.9	11.4	12.3	13.1	13.6	14.9	14.8	14.2	13.9	13.23
T ₃	11.7	12.3	12.8	13.4	13.5	14.7	14.8	14.1	13.6	13.43
T ₄	12.6	12.7	13.4	13.6	14.2	14.3	14.5	14.1	13.4	13.64
T ₅	12.3	12.6	12.9	13.1	13.2	13.8	14.0	13.8	13.1	13.20
Mean	11.92	12.30	12.80	13.22	13.62	14.26	14.32	13.94	13.46	-

CD at 5% = Season (A) = 0.89; Treatment (B) = 0.66

Table 7.16. Effect of varying doses of P on leaf Zn (ppm) content of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	11.6	12.3	12.6	12.7	13.0	13.6	13.4	13.6	13.2	12.89
T ₂	11.2	11.8	12.6	12.8	13.6	13.8	14.5	14.2	13.6	13.12
T ₃	11.9	12.1	12.5	12.7	13.6	13.9	14.6	14.1	13.6	13.22
T ₄	12.1	12.6	13.5	13.6	14.0	14.2	14.3	14.1	13.5	13.54
T ₅	12.1	12.5	12.7	13.2	13.0	13.6	14.0	13.6	13.0	13.08
Mean	11.78	12.26	12.78	13.00	13.44	13.82	14.16	13.92	13.38	-

CD at 5% = Season (A) = 0.73; Treatment (B) = 0.55

Table 7.17. Effect of varying doses of P on leaf Cu (ppm) content of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	7.9	8.2	8.4	8.6	8.7	8.7	8.9	11.3	9.3	8.89
T ₂	7.7	8.1	8.3	8.4	8.8	8.7	9.1	10.2	9.5	8.76
T ₃	8.0	8.2	8.3	8.3	8.5	8.7	8.9	11.1	9.3	8.81
T ₄	7.8	8.2	8.2	8.4	8.6	8.8	9.6	11.2	9.1	8.88
T ₅	7.9	8.1	8.2	8.4	8.8	8.9	9.2	11.1	9.6	8.91
Mean	7.86	8.16	8.28	8.42	8.68	8.76	9.4	10.98	9.36	-

CD at 5% = Season (A) = 0.35; Treatment (B) = 0.26

Table 7.18. Effect of varying doses of P on leaf Cu (ppm) content of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	7.3	8.0	8.1	8.3	8.6	8.8	9.0	9.7	9.0	8.53
T ₂	7.5	7.6	8.0	8.3	8.8	8.9	9.2	10.1	9.3	8.63
T ₃	7.6	8.1	8.3	8.4	8.5	8.8	9.2	10.7	9.3	8.77
T ₄	7.7	7.9	8.2	8.4	8.6	8.7	9.3	11.2	9.5	8.83
T ₅	6.9	8.1	8.3	8.4	8.5	8.7	9.5	11.1	9.5	8.78
Mean	7.40	7.94	8.18	8.36	8.60	8.78	9.24	10.56	9.32	-

CD at 5% = Season (A) = 0.34; Treatment (B) = 0.26

Table 7.19. Effect of varying doses of P on leaf Fe (ppm) content of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	110.4	120.3	88.3	120.4	125.3	120.3	124.8	129.2	121.3	117.81
T ₂	100.7	121.3	83.2	120.6	124.3	127.3	129.7	132.6	123.9	118.18
T ₃	105.8	119.8	85.1	120.9	120.4	126.8	127.8	135.7	124.4	118.52
T ₄	107.2	121.6	81.3	120.6	118.6	126.7	136.1	138.4	121.5	119.11
T ₅	106.1	121.9	87.6	122.7	116.3	123.4	137.9	138.6	119.7	118.69
Mean	106.04	120.98	83.90	121.04	120.98	124.90	131.26	134.90	122.16	-

CD at 5% = Season (A) = 4.62; Treatment (B) = 3.44

Table 7.20. Effect of varying doses of P on leaf Fe (ppm) content of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	90.7	103.2	79.9	110.2	117.1	109.8	109.9	113.2	115.4	105.49
T ₂	107.2	120.1	81.2	120.7	125.1	127.7	128.1	133.2	121.4	118.30
T ₃	103.4	117.6	81.7	120.3	121.2	125.6	128.0	135.1	123.8	117.41
T ₄	106.9	120.6	84.6	121.7	125.8	127.6	133.2	130.4	120.8	120.06
T ₅	104.1	116.1	83.6	123.1	126.3	127.8	135.6	138.1	121.3	119.55
Mean	104.46	115.52	82.2	119.2	123.1	123.7	126.96	131.80	120.54	-

CD at 5% = Season (A) = 6.74; Treatment (B) = 5.02

Mean leaf Fe content has not been affected by increase in applied P. All the treatments have been found to be at par. However, during stabilization period, i.e., August and September, only T₄ and T₅ have been found to be superior and at par. As a general trend, to any further application of P after T₄ the Fe content in leaves has either started decreasing or found to be at par with T₄ level (Tables No. 7.19 and 7.20).

4. 4.4 Effect of P on yield and quality

Application of P has increased the individual fruit weight. Highest fruit weight has been produced at T₅ level. Nevertheless, the increase of weight from T₄ to T₅ has been found to be very minimal. Hence T₄ and T₅ has proved statistically at par. Same kind of trend has been found in number of fruits/tree and TSS percentage.

The juice percentage of fruits has increased upto T₄ level, then again it has dropped. Still T₄ and T₅ has been found to be statistically at par.

Application of P has increased acidity percentage in fruits. Highest percentage has been recorded by T₅. Nevertheless, T₄ also has been found to be at par with T₅.

4. 5 Effect of varying dose of K on leaf nutrient status, yield and quality

4.5.1 Effect on leaf primary nutrients

The increase in application of K has increased N content in leaves from T₁ level upto T₄ level. Then on every incremental addition of K has reduced the leaf N content. In second year, the reduction has been found to be drastic

Table 7.21. Effect of varying doses of P on yield and quality parameters of Kinnow during 1999

Treatments	Individual fruit wt. (g)	No. of fruits/tree	Juice (%)	TSS (%)	Titration acidity (%)
T ₁	123.6	36.1	40.13	8.76	0.79
T ₂	129.3	36.2	42.02	8.89	0.83
T ₃	140.3	37.8	43.18	9.04	0.92
T ₄	159.8	40.2	48.28	10.30	1.01
T ₅	159.9	41.1	47.22	10.40	1.03
CD at 5%	7.82	1.78	2.39	0.52	0.02

Table 7.22. Effect of varying doses of P on yield and quality parameters of Kinnow during 2000

Treatments	Individual fruit wt. (g)	No. of fruits/tree	Juice (%)	TSS (%)	Titration acidity (%)
T ₁	125.7	39.2	41.40	8.02	0.82
T ₂	128.4	39.6	41.82	8.68	0.85
T ₃	138.3	40.5	45.63	9.26	0.96
T ₄	160.2	40.5	49.23	10.47	0.98
T ₅	161.3	41.8	49.21	10.49	1.02
CD at 5%	8.21	2.11	3.20	0.36	0.04

Table 8.1. Effect of varying doses of K on leaf N (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	2.34	2.40	2.44	1.38	1.38	1.50	1.85	1.75	1.50	1.838
T ₂	2.46	2.48	2.55	1.69	1.55	2.68	2.73	2.70	2.65	2.388
T ₃	2.35	2.46	2.58	1.66	1.57	2.75	2.80	2.74	2.67	2.398
T ₄	2.17	2.36	2.56	1.82	1.78	2.87	2.90	2.85	2.63	2.438
T ₅	2.24	2.27	2.56	1.83	1.80	2.84	2.90	2.83	2.66	2.437
Mean	2.312	2.394	2.538	1.676	1.616	2.528	2.636	2.574	2.422	-

CD at 5% = Season (A) = 0.109; Treatment (B) = 0.080

Table 8.2. Effect of varying doses of K on leaf N (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	2.37	2.42	2.45	1.36	1.39	1.46	1.82	1.76	1.52	1.839
T ₂	2.48	2.50	2.57	1.65	1.57	2.63	2.74	2.72	2.63	2.388
T ₃	2.38	2.45	2.52	1.69	1.62	2.76	2.80	2.73	2.65	2.400
T ₄	2.25	2.41	2.53	1.81	1.81	2.82	2.85	2.80	2.68	2.440
T ₅	2.27	2.38	2.46	1.79	1.66	2.79	2.88	2.82	2.65	2.411
Mean	2.350	2.432	2.506	1.660	1.610	2.492	2.618	2.566	2.426	-

CD at 5% = Season (A) = 0.146; Treatment (B) = 0.060

Table 8.3. Effect of varying doses of K on leaf P (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.16	0.17	0.18	0.16	0.15	0.18	0.19	0.20	0.22	0.179
T ₂	0.15	0.16	0.18	0.17	0.14	0.19	0.19	0.20	0.23	0.179
T ₃	0.17	0.19	0.18	0.16	0.13	0.18	0.20	0.22	0.24	0.186
T ₄	0.19	0.20	0.19	0.16	0.14	0.19	0.21	0.24	0.25	0.197
T ₅	0.18	0.20	0.20	0.15	0.12	0.20	0.21	0.24	0.27	0.197
Mean	0.170	0.184	0.186	0.160	0.136	0.188	0.200	0.220	0.242	-

CD at 5% = Season (A) = 0.024; Treatment (B) = 0.019

Table 8.4. Effect of varying doses of K on leaf P (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.16	0.16	0.17	0.15	0.14	0.19	0.20	0.21	0.22	0.178
T ₂	0.16	0.17	0.19	0.16	0.15	0.20	0.20	0.21	0.23	0.186
T ₃	0.18	0.19	0.19	0.16	0.14	0.21	0.21	0.22	0.24	0.193
T ₄	0.19	0.21	0.18	0.17	0.13	0.22	0.23	0.24	0.25	0.202
T ₅	0.18	0.21	0.19	0.17	0.15	0.22	0.22	0.26	0.27	0.207
Mean	0.174	0.188	0.184	0.162	0.142	0.208	0.212	0.228	0.242	-

CD at 5% = Season (A) = 0.039; Treatment (B) = 0.029

Table 8.5. Effect of varying doses of K on leaf K (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	1.45	1.51	1.56	1.31	1.18	1.39	1.60	1.68	1.69	1.485
T ₂	1.46	1.51	1.55	1.32	1.13	1.41	1.63	1.66	1.68	1.483
T ₃	1.55	1.59	1.62	1.37	1.34	1.62	1.76	1.80	1.79	1.604
T ₄	1.52	1.60	1.64	1.339	1.30	1.65	1.78	1.79	1.81	1.608
T ₅	1.65	1.67	1.69	1.34	1.49	1.82	1.83	1.88	1.89	1.696
Mean	1.526	1.576	1.612	1.346	1.288	1.578	1.720	1.762	1.772	-

CD at 5% = Season (A) = 0.094; Treatment (B) = 0.088

Table 8.6. Effect of varying doses of K on leaf K (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	1.36	1.45	1.50	1.27	1.18	1.64	1.67	1.72	1.79	1.508
T ₂	1.40	1.46	1.52	1.30	1.20	1.59	1.62	1.72	1.77	1.509
T ₃	1.48	1.47	1.53	1.39	1.28	1.68	1.76	1.79	1.75	1.570
T ₄	1.64	1.67	1.74	1.39	1.45	1.68	1.69	1.74	1.79	1.643
T ₅	1.66	1.66	1.69	1.32	1.47	1.76	1.77	1.79	1.80	1.658
Mean	1.508	1.542	1.596	1.334	1.316	1.670	1.702	1.752	1.780	-

CD at 5% = Season (A) = 0.097; Treatment (B) = 0.081

compared to first year. However, all the treatments mean values including control have been found to be statistically at par. During stabilization period of July to September. T₄ and T₅ have been found to be at par and superior to rest of the treatments (Tables No. 8.1 and 8.2).

The increase in K has increased the leaf P content. However, the increase in P after T₄ level has been observed to be very minimal. The mean P values have revealed that all treatments including control are at par. During stabilization period of September and October T₃ and T₄ have consistently proved superior and statistical parity. T₃ has emerged as next best (Tables No.8.3 and 8.4).

Increase in K application has increased the leaf K content. The mean K values on leaves have revealed that applied K and leaf K has positive correlation. T₅ has been recorded highest values, even though it has been found to be statistically at par with T₄. T₄ has been in turn found to be at par with T₃. T₁ has recorded the lowest value followed by T₂. During stabilization period of August to October too more or less similar trend has been continued (Tables No.8.5 and 8.6).

4.5.2 Effect on leaf secondary elements

Mean leaf Ca values have revealed that the increase in K application has increased the Ca values upto T₃ and then on it has decreased. In the first year the lowest value has been recorded by T₅ followed by T₄ which are lower than the control (T₁) value. However, in second year the lowest value has been

Table 8.7. Effect of varying doses of K on leaf Ca (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	3.63	3.71	3.77	3.91	4.28	4.38	4.60	4.66	4.71	4.172
T ₂	3.68	3.77	3.80	3.98	4.28	4.37	4.40	4.53	4.75	4.173
T ₃	3.65	3.80	3.82	3.96	4.22	4.42	4.51	4.53	4.77	4.187
T ₄	3.63	3.69	3.88	3.96	4.15	4.37	4.45	4.58	4.70	4.157
T ₅	3.65	3.73	3.76	3.99	4.17	4.36	4.42	4.62	4.70	4.156
Mean	3.648	3.740	3.806	3.960	4.200	4.380	4.476	4.584	4.726	-

CD at 5% = Season (A) = 0.189; Treatment (B) = 0.131

Table 8.8. Effect of varying doses of K on leaf Ca (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	3.60	3.69	3.74	3.85	4.01	4.21	4.60	4.64	4.68	4.113
T ₂	3.76	3.80	3.83	3.91	4.17	4.40	4.53	4.55	4.70	4.183
T ₃	3.71	3.77	3.80	3.95	4.40	4.38	4.41	4.50	4.78	4.189
T ₄	3.72	3.75	3.76	3.95	4.18	4.37	4.53	4.62	4.75	4.181
T ₅	3.68	3.71	3.85	3.96	4.12	4.32	4.51	4.59	4.71	4.161
Mean	3.694	3.744	3.796	3.924	4.176	4.336	4.516	4.580	4.724	-

CD at 5% = Season (A) = 0.083; Treatment (B) = 0.076

Table 8.9. Effect of varying doses of K on leaf Mg (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.57	0.46	0.41	0.36	0.39	0.39	0.40	0.43	0.39	0.417
T ₂	0.54	0.49	0.43	0.39	0.35	0.40	0.42	0.44	0.41	0.436
T ₃	0.58	0.45	0.42	0.37	0.35	0.38	0.41	0.44	0.40	0.422
T ₄	0.56	0.46	0.42	0.39	0.35	0.36	0.41	0.43	0.34	0.418
T ₅	0.56	0.44	0.40	0.35	0.35	0.39	0.42	0.44	0.41	0.417
Mean	0.562	0.460	0.416	0.372	0.348	0.384	0.412	0.436	0.390	-

CD at 5% = Season (A) = 0.109; Treatment (B) = 0.080

Table 8.10. Effect of varying doses of K on leaf Mg (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.58	0.46	0.42	0.37	0.33	0.38	0.41	0.42	0.39	0.418
T ₂	0.55	0.47	0.44	0.39	0.35	0.39	0.42	0.43	0.41	0.428
T ₃	0.57	0.44	0.41	0.35	0.34	0.40	0.41	0.43	0.41	0.418
T ₄	0.51	0.47	0.43	0.39	0.34	0.37	0.41	0.43	0.41	0.418
T ₅	0.58	0.45	0.46	0.35	0.33	0.36	0.40	0.42	0.40	0.417
Mean	0.558	0.458	0.432	0.370	0.338	0.380	0.410	0.426	0.404	-

CD at 5% = Season (A) = 0.047; Treatment (B) = 0.021

Table 8.11. Effect of varying doses of K on leaf S (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.30	0.31	0.36	0.39	0.36	0.31	0.34	0.35	0.32	0.338
T ₂	0.28	0.29	0.38	0.44	0.40	0.34	0.35	0.30	0.28	0.334
T ₃	0.26	0.27	0.36	0.42	0.35	0.35	0.39	0.35	0.31	0.340
T ₄	0.25	0.27	0.38	0.42	0.36	0.34	0.39	0.35	0.34	0.342
T ₅	0.30	0.31	0.35	0.42	0.37	0.33	0.40	0.35	0.29	0.346
Mean	0.278	0.290	0.362	0.418	0.368	0.334	0.374	0.340	0.308	-

CD at 5% = Season (A) = 0.015; Treatment (B) = 0.015

Table 8.12. Effect of varying doses of K on leaf S (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.24	0.31	0.36	0.40	0.35	0.35	0.39	0.35	0.31	0.340
T ₂	0.28	0.31	0.38	0.42	0.37	0.32	0.37	0.34	0.32	0.346
T ₃	0.30	0.30	0.32	0.39	0.37	0.32	0.40	0.36	0.30	0.340
T ₄	0.28	0.29	0.36	0.41	0.35	0.35	0.41	0.35	0.31	0.346
T ₅	0.26	0.28	0.37	0.41	0.36	0.35	0.49	0.36	0.32	0.356
Mean	0.272	0.298	0.358	0.406	0.360	0.346	0.412	0.352	0.312	-

CD at 5% = Season (A) = 0.063; Treatment (B) = 0.016

recorded by T₁ followed by T₃. The highest mean value has been recorded by T₃. During stabilization period the trend has become ambiguous. No conclusion could be derived from it (Tables No. 8.7 and 8.8).

The applied K and leaf Mg content have shown a negative correlation. The highest mean Mg value has been observed in T₂ where the applied K was lowest. Further, increase in K has decreased the leaf Mg content. During stabilization period of July to October also same trend has been observed (Tables No. 8.9 and 8.10).

The applied K at higher level has produced a positive interaction with leaf S. The K applied beyond T₃ level has increased the leaf S level. The highest S value has been recorded by T₅ followed by T₄. At lower K application level clear trend has not emerged. During stabilization also it has produced an ambiguous trend (Tables No. 8.11 and 8.12).

4.5.3 Effect on leaf micronutrients

The mean Mn values have shown a positive trend till T₄ for every increase in K application. The maximum mean Mn value has been recorded in T₄. However, except T₁ all other treatments have been found to be statistically at par. During stabilization period of July to August also highest value of leaf Mn has been recorded in T₄ (Tables No. 8.13 and 8.14).

The mean Zn values have shown a positive trend with applied K. However, the maximum value has been recorded in T₄ level beyond that every increase in K addition has resulted in reduction of leaf Zn content. The T₄

Table 8.13. Effect of varying doses of K on leaf Mn (ppm) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	21.2	35.6	29.1	49.8	41.3	62.1	61.2	48.9	34.2	42.60
T ₂	23.0	31.4	29.2	54.6	43.8	61.2	61.3	49.2	35.6	43.25
T ₃	22.4	36.1	29.2	48.9	41.2	59.7	61.2	55.4	37.4	43.50
T ₄	25.1	33.8	27.3	55.4	43.0	63.2	65.1	51.2	33.6	44.18
T ₅	24.6	33.6	28.1	47.6	44.8	60.2	63.2	55.6	35.4	43.67
Mean	23.26	34.1	28.58	51.26	42.82	61.28	62.4	52.06	35.26	-

CD at 5% = Season (A) = 2.61; Treatment (B) = 2.01

Table 8.14. Effect of varying doses of K on leaf Mn (ppm) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	24.3	33.2	28.5	54.3	41.7	55.8	58.3	53.1	41.2	41.15
T ₂	23.0	35.2	29.2	55.2	46.4	60.2	61.2	51.3	35.4	44.12
T ₃	22.4	33.2	26.8	56.1	45.2	52.1	58.4	58.1	37.3	43.28
T ₄	23.1	35.8	27.3	47.6	48.4	59.3	59.3	58.7	31.2	43.41
T ₅	25.1	31.2	27.3	49.6	43.0	57.6	59.8	54.2	33.2	42.33
Mean	23.58	33.72	27.82	52.56	44.94	57.0	59.4	55.08	35.66	-

CD at 5% = Season (A) = 2.58; Treatment (B) = 1.90

Table 8.15. Effect of varying doses of K on leaf Zn (ppm) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	10.3	10.4	10.8	11.7	12.8	13.7	13.6	13.5	11.9	12.07
T ₂	10.4	10.6	11.2	12.0	12.8	13.6	13.5	13.3	11.8	12.13
T ₃	12.6	12.9	13.6	13.8	13.9	14.1	14.2	14.6	13.7	13.71
T ₄	12.9	13.6	14.2	14.7	14.9	14.9	15.1	15.3	14.3	14.43
T ₅	11.5	12.1	12.6	14.3	14.4	14.7	15.0	15.4	14.1	13.78
Mean	11.54	11.92	12.48	13.3	13.76	14.2	14.28	14.42	13.16	-

CD at 5% = Season (A) = 0.76; Treatment (B) = 0.57

Table 8.16. Effect of varying doses of K on leaf Zn (ppm) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	11.9	12.9	13.2	13.6	13.8	14.4	14.5	13.4	13.1	13.42
T ₂	11.6	11.9	12.3	13.1	13.6	14.2	14.2	14.0	13.9	13.20
T ₃	12.1	12.9	13.1	13.4	13.7	14.0	14.0	13.7	13.2	13.34
T ₄	12.6	12.7	13.4	13.6	14.1	14.3	14.4	14.1	13.5	13.63
T ₅	12.1	12.6	13.1	13.5	14.2	14.4	14.5	14.0	13.6	13.55
Mean	12.06	12.6	13.0	13.44	13.88	14.26	14.32	13.84	13.46	-

CD at 5% = Season (A) = 0.73; Treatment (B) = 0.55

Table 8.17. Effect of varying doses of K on leaf Cu (ppm) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	7.1	7.2	7.2	7.6	8.2	8.4	8.7	9.8	8.7	8.10
T ₂	7.3	7.6	7.7	7.8	8.0	8.2	8.6	9.2	8.7	8.12
T ₃	7.9	8.1	8.7	9.2	9.6	9.7	10.1	10.5	9.7	9.27
T ₄	7.3	7.7	7.9	8.3	8.5	8.6	9.1	10.4	9.6	8.60
T ₅	7.1	7.3	7.3	7.5	8.2	8.4	9.5	8.4	8.3	8.00
Mean	7.34	7.58	7.76	8.06	8.5	8.66	9.2	9.66	9.0	-

CD at 5% = Season (A) = 0.46; Treatment (B) = 0.34

Table 8.18. Effect of varying doses of K on leaf Cu (ppm) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	7.7	7.8	8.2	8.3	8.7	8.9	10.2	11.8	9.1	8.96
T ₂	7.5	7.7	8.4	8.5	8.6	9.5	10.4	9.7	9.5	8.86
T ₃	7.6	8.1	8.3	8.5	8.7	8.8	9.6	11.2	9.8	8.95
T ₄	7.3	7.8	7.9	8.3	8.5	8.9	10.3	11.2	9.2	8.82
T ₅	7.5	7.7	8.2	8.0	8.5	8.7	9.0	10.7	9.3	8.62
Mean	7.52	7.82	8.2	8.32	8.6	8.96	9.9	10.92	9.38	-

CD at 5% = Season (A) = 0.43; Treatment (B) = 0.26

Table 8.19. Effect of varying doses of K on leaf Fe (ppm) content of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	88.5	101.2	79.9	102.6	100.2	104.2	122.6	127.5	119.2	105.10
T ₂	94.2	108.2	76.6	110.2	100.4	103.4	110.2	117.8	116.3	104.14
T ₃	100.4	111.3	96.2	107.2	104.2	113.4	121.6	126.7	109.3	110.03
T ₄	98.7	102.4	95.2	106.3	100.4	105.4	107.2	117.6	112.8	105.10
T ₅	88.5	101.2	79.9	102.6	101.8	104.6	121.3	127.5	119.7	105.23
Mean	94.06	104.86	85.56	105.78	101.4	106.2	116.58	123.42	115.46	-

CD at 5% = Season (A) = 7.71; Treatment (B) = 6.33

Table 8.20. Effect of varying doses of K on leaf Fe (%) content of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	100.9	103.4	99.8	120.4	120.8	109.8	117.6	121.5	104.8	111.0
T ₂	97.1	101.4	100.7	107.4	100.4	103.8	126.5	128.1	117.4	109.2
T ₃	97.8	114.3	106.5	110.8	100.3	107.4	110.8	121.3	108.7	108.65
T ₄	98.3	101.4	100.4	117.4	101.3	103.2	116.6	127.5	101.4	106.94
T ₅	100.2	105.2	90.7	120.4	120.9	105.6	118.2	119.4	102.2	109.2
Mean	98.86	105.14	99.62	115.28	108.74	105.96	116.94	123.56	106.9	-

CD at 5% = Season (A) = 0.677; Treatment (B) = 5.04

value in the first year has been significantly different from other treatments. However, during second year though it has been numerically proved superior, statistically found to be at par with other treatments. During stabilization period of first year the T₄ has been numerically superior and in second year it has been found to be at par with T₅ (Tables No.8.15 and 8.16).

The maximum mean Cu value has been observed in T₃ level beyond which it has started decreasing. However, T₃ has been found to be statistically superior only during first year. During second year it has shown only numerical superiority. During the peak period of September again T₃ has proved its numerical superiority in first year and statistical superiority in second year (Tables No. 8.17 and 8.18).

The mean leaf Fe content have shown that applied K and Fe has no relationship. All the treatments have been found to be statistically at par. During stabilization period of August and September the leaf Fe contents have shown a perplexed trend (Tables No. 8.19 and 8.20).

4.4.4. Effect of varying dose of K on yield and quality

The application of K has increased fruit weight, number of fruits/tree, juice percentage and TSS till T₄ level. Further increase in K has shown a diminishing effect on these parameters. On the other hand, fruit acidity has been found to be increased by every addition of K and the highest value has been found to be at T₅ level. Nevertheless, T₄ and T₅ has been found to be at par with T₅.

Table 8.21. Effect of varying doses of K on yield and quality parameters of Kinnow during 1999

Treatments	Individual fruit wt. (g)	No. of fruits/tree	Juice (%)	TSS (%)	Titration acidity (%)
T ₁	123.6	34.2	40.28	8.72	0.71
T ₂	126.7	38.6	41.82	8.69	0.78
T ₃	135.2	43.2	45.16	9.23	0.96
T ₄	158.7	48.1	48.12	10.21	1.06
T ₅	150.2	45.9	47.99	9.90	1.08
CD at 5%	7.92	2.10	1.32	0.29	0.02

Table 8.22. Effect of varying doses of K on yield and quality parameters of Kinnow during 2000

Treatments	Individual fruit wt. (g)	No. of fruits/tree	Juice (%)	TSS (%)	Titration acidity (%)
T ₁	122.7	33.8	40.17	8.13	0.72
T ₂	123.1	35.6	40.28	8.71	0.84
T ₃	146.2	47.2	43.68	9.73	0.93
T ₄	162.8	49.8	47.12	10.36	1.02
T ₅	153.4	47.4	46.66	9.86	1.03
CD at 5%	8.13	2.27	1.76	0.41	0.02

On all these parameters T₄ has proven significantly superior over all other treatments

4.6 Effect of time of application of N on leaf nutrient status

4.6.1. Effect on leaf primary nutrients

Time of application of nitrogenous fertilizer has produced varying degree of effect on different nutrient contents of Kinnow leaves. Amongst treatments highest mean value of leaf N content has reported from T₁ and T₂ on both the years of study. However, highest values during July to October which is stabilization period for N have been observed in T₃. Moreover T₃ is the only treatment which shows stabilization of values (tables No. 9.1; 9.2 and Fig.13).

Time of application has produced a marked effect on P content in leaves. Amongst the treatments during the first year of the study T₁ has recorded the highest mean value followed by T₃. In second year the trend has been reversed i.e. T₃ has produced highest value followed by T₁. In second year, during stabilization period i.e. between July and August and September and October except T₃ all other treatments values have been found to be dropping. Only T₃ values have been found to be increasing (Tables No. 9.3 and 9.4).

The leaf K content has shown a clear trend. Though mean values have been observed to be at par for all the treatments on both the years, T₃ has produced significantly higher values than the rest of the treatments during stabilization period i.e. between July to October (Tables No. 9.5 and 9.6).

Table 9.1. Effect of time of application of fertilizer on leaf N (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	2.15	2.43	2.47	2.50	2.67	2.77	2.68	2.81	2.77	2.583
T ₂	2.22	2.48	2.51	2.34	2.71	2.71	2.64	2.80	2.67	2.564
T ₃	2.18	2.38	2.53	1.86	1.82	2.88	2.92	2.85	2.73	2.461
T ₄	2.13	2.37	2.45	1.82	1.66	1.58	2.89	2.63	2.59	2.236
Mean	2.170	2.415	2.490	2.130	2.215	2.485	2.783	2.773	2.690	-

CD at 5% = Season (A) = 0.121; Treatment (B) = 0.081

Table 9.2. Effect of time of application of fertilizer on leaf N (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	2.31	2.51	2.53	2.59	2.68	2.89	2.71	2.83	2.74	2.643
T ₂	2.27	2.49	2.47	2.37	2.75	2.74	2.59	2.89	2.72	2.588
T ₃	2.21	2.49	2.53	1.92	1.79	2.87	2.93	2.83	2.68	2.474
T ₄	2.17	2.40	2.49	1.86	1.59	1.47	2.86	2.60	2.51	2.217
Mean	2.240	2.473	2.505	2.185	2.203	2.493	2.772	2.772	2.660	-

CD at 5% = Season (A) = 0.159; Treatment (B) = 0.106

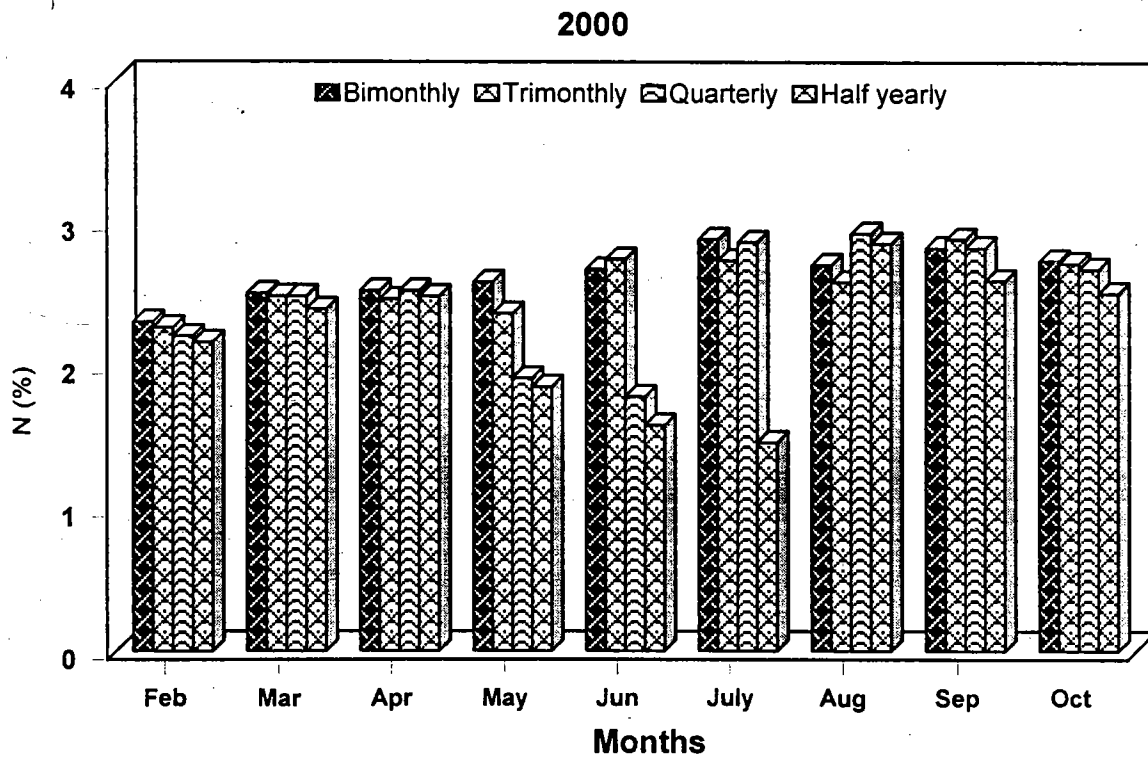
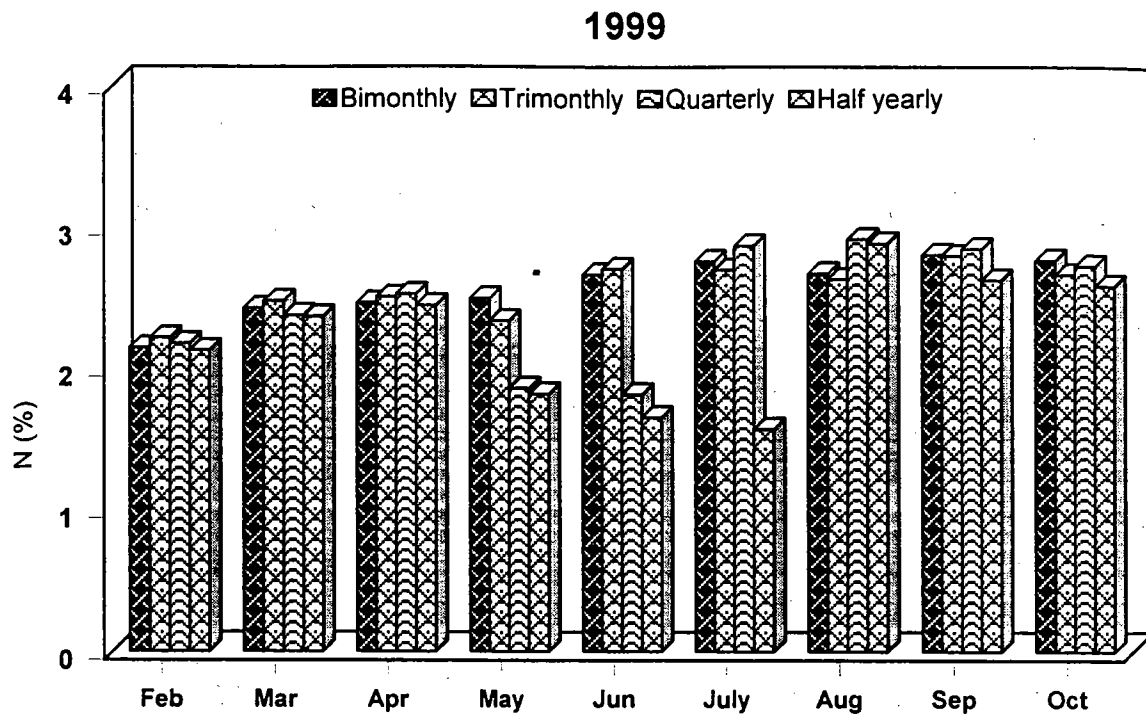


Fig. 13. Effect of time of application of fertilizer on leaf N (%)

Table 9.3. Effect of time of application of fertilizer on leaf P (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.19	0.24	0.21	0.16	0.19	0.21	0.19	0.21	0.24	0.204
T ₂	0.16	0.19	0.16	0.11	0.15	0.18	0.17	0.20	0.22	0.174
T ₃	0.17	0.24	0.22	0.14	0.12	0.20	0.18	0.22	0.25	0.193
T ₄	0.15	0.19	0.17	0.12	0.13	0.16	0.16	0.21	0.21	0.167
Mean	0.168	0.215	0.190	0.133	0.147	0.188	0.175	0.210	0.230	-

CD at 5% = Season (A) = 0.020; Treatment (B) = 0.007

Table 9.4. Effect of time of application of fertilizer on leaf P (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.18	0.19	0.15	0.10	0.13	0.16	0.15	0.19	0.19	0.160
T ₂	0.17	0.17	0.13	0.11	0.11	0.17	0.17	0.19	0.21	0.159
T ₃	0.17	0.19	0.16	0.14	0.13	0.21	0.20	0.24	0.25	0.188
T ₄	0.13	0.15	0.11	0.10	0.09	0.16	0.15	0.17	0.22	0.142
Mean	0.103	0.175	0.137	0.112	0.115	0.175	0.168	0.197	0.218	-

CD at 5% = Season (A) = 0.030; Treatment (B) = 0.007

Table 9.5. Effect of time of application of fertilizer on leaf K (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	1.47	1.53	1.53	1.34	1.26	1.60	1.64	1.67	1.69	1.523
T ₂	1.49	1.51	1.57	1.38	1.29	1.61	1.64	1.68	1.71	1.542
T ₃	1.44	1.50	1.59	1.36	1.21	1.69	1.71	1.79	1.83	1.569
T ₄	1.39	1.47	1.51	1.27	1.16	1.62	1.69	1.71	1.78	1.511
Mean	1.448	1.498	1.550	1.338	1.230	1.630	1.670	1.713	1.753	-

CD at 5% = Season (A) = 0.097; Treatment (B) = 0.054

Table 9.6. Effect of time of application of fertilizer on leaf K (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	1.51	1.53	1.54	1.36	1.28	1.61	1.63	1.69	1.70	1.539
T ₂	1.48	1.52	1.55	1.39	1.23	1.64	1.64	1.67	1.72	1.538
T ₃	1.45	1.52	1.57	1.32	1.26	1.71	1.73	1.80	1.88	1.582
T ₄	1.47	1.51	1.52	1.32	1.28	1.65	1.68	1.73	1.79	1.550
Mean	1.478	1.520	1.545	1.348	1.262	1.653	1.670	1.723	1.773	-

CD at 5% = Season (A) = 0.091; Treatment (B) = 0.050

Table 9.7. Effect of time of application of fertilizer on leaf Ca (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	3.32	3.36	3.62	3.93	4.11	4.22	4.26	4.29	4.31	3.926
T ₂	3.61	3.59	3.72	4.08	4.31	4.34	4.37	4.41	4.44	4.097
T ₃	3.72	3.76	3.81	4.15	4.38	4.49	4.51	4.69	4.79	4.256
T ₄	3.66	3.72	3.80	4.09	4.27	4.39	4.48	4.61	4.70	4.191
Mean	3.555	3.608	3.738	4.063	4.268	4.360	4.405	4.500	4.560	-

CD at 5% = Season (A) = 0.264; Treatment (B) = 0.176

Table 9.8. Effect of time of application of fertilizer on leaf Ca (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	3.48	3.50	3.53	3.71	3.89	3.96	4.13	4.28	4.33	3.868
T ₂	3.68	3.69	3.70	3.93	4.12	4.39	4.41	4.52	4.46	4.100
T ₃	3.75	3.75	3.77	3.97	4.31	4.45	4.47	4.68	4.81	4.218
T ₄	3.69	3.70	3.73	3.92	4.26	4.36	4.42	4.59	4.76	4.159
Mean	3.650	3.660	3.683	3.883	4.145	4.290	4.357	4.518	4.590	-

CD at 5% = Season (A) = 0.321; Treatment (B) = 0.149

Table 9.9. Effect of time of application of fertilizer on leaf Mg (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.63	0.57	0.50	0.43	0.41	0.42	0.42	0.39	0.35	0.458
T ₂	0.59	0.51	0.44	0.40	0.39	0.41	0.44	0.40	0.38	0.440
T ₃	0.57	0.51	0.43	0.39	0.36	0.39	0.43	0.43	0.42	0.437
T ₄	0.59	0.52	0.47	0.41	0.40	0.40	0.41	0.37	0.35	0.436
Mean	0.595	0.528	0.460	0.408	0.390	0.405	0.425	0.398	0.375	-

CD at 5% = Season (A) = 0.023; Treatment (B) = 0.015

Table 9.10. Effect of time of application of fertilizer on leaf Mg (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.59	0.55	0.52	0.48	0.43	0.44	0.43	0.43	0.37	0.471
T ₂	0.48	0.43	0.40	0.38	0.36	0.39	0.42	0.41	0.39	0.407
T ₃	0.47	0.43	0.41	0.37	0.36	0.38	0.40	0.44	0.41	0.408
T ₄	0.51	0.47	0.44	0.41	0.39	0.40	0.42	0.39	0.36	0.421
Mean	0.513	0.470	0.443	0.410	0.385	0.403	0.418	0.418	0.383	-

CD at 5% = Season (A) = 0.027; Treatment (B) = 0.018

Table 9.11. Effect of time of application of fertilizer on leaf S (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.38	0.33	0.36	0.39	0.34	0.31	0.39	0.35	0.34	0.354
T ₂	0.28	0.32	0.37	0.39	0.35	0.33	0.40	0.37	0.35	0.351
T ₃	0.42	0.39	0.42	0.43	0.40	0.37	0.45	0.37	0.37	0.402
T ₄	0.41	0.42	0.44	0.45	0.42	0.40	0.42	0.39	0.35	0.411
Mean	0.373	0.365	0.398	0.415	0.377	0.353	0.415	0.370	0.353	-

CD at 5% = Season (A) = 0.019; Treatment (B) = 0.013

Table 9.12. Effect of time of application of fertilizer on leaf S (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.41	0.38	0.39	0.42	0.35	0.37	0.37	0.34	0.33	0.373
T ₂	0.45	0.38	0.41	0.43	0.41	0.39	0.41	0.35	0.36	0.399
T ₃	0.36	0.39	0.42	0.43	0.40	0.38	0.42	0.39	0.39	0.398
T ₄	0.44	0.44	0.44	0.46	0.40	0.37	0.45	0.35	0.34	0.410
Mean	0.415	0.398	0.415	0.435	0.390	0.378	0.413	0.357	0.355	-

CD at 5% = Season (A) = 0.020; Treatment (B) = 0.013

4.6.2 Effect on leaf secondary nutrients

Except T₁ all the other treatments have produced higher mean Ca values which have been found to be at par. However during stabilization period only T₃ and T₄ have produced consistently higher values (Tables No. 9.7 and 9.8).

Leaf Mg content has shown an unique trend. Here mean February value has been found to be the highest. Amongst the treatments only T₁ has produced highest mean value which is the resultant of prolonged higher values from the month of February to August in first year and February to September in second year. However during stabilization period T₃ has also produced higher values which have been found to be at par with T₁ (Tables No. 9.9 and 9.10).

Leaf S content has produced confusing trend. The mean S values of T₂ and T₄ have been observed to be at par on both the years. However T₂ has also produced higher values which has been found to be at par with T₂ and T₄ in second year. During stabilization period only T₁ and T₃ has produced consistent values on both the years (Tables No. 9.11 and 9.12).

4.6.3 Effect on leaf micronutrients

Mean Mn values have shown that T₁, T₂ and T₃ are statistically equal. However during stabilization period i.e. between July to September only T₁ and T₃ have been observed to produce higher values (Tables No. 9.13 and 9.14).

During first year, even though mean Zn values of all treatments have been observed to be at par only T₂ and T₃ have produced similar results, in second year. Amongst T₂ and T₃ only T₃ has recorded consistently higher

Table 9.13. Effect of time of application of fertilizer on Mn (ppm) content of leaves of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	20.1	34.6	26.1	56.9	48.7	60.2	61.5	60.9	39.3	45.37
T ₂	23.5	35.7	27.2	57.5	49.8	59.7	60.1	60.7	39.1	45.92
T ₃	23.2	33.9	27.6	58.1	48.3	61.3	63.8	60.3	38.8	46.14
T ₄	22.4	33.1	26.0	56.2	47.2	58.2	58.4	58.1	37.3	44.10
Mean	22.30	34.33	26.73	57.18	48.50	59.85	60.95	60.00	38.63	-

CD at 5% = Season (A) = 2.37; Treatment (B) = 1.58

Table 9.14. Effect of time of application of fertilizer on Mn (ppm) content of leaves of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	24.2	37.3	28.1	48.8	50.3	61.4	62.4	62.2	39.0	46.00
T ₂	24.7	37.9	29.3	49.7	50.9	60.7	60.7	61.8	38.7	46.01
T ₃	24.3	37.3	29.7	50.2	51.8	61.9	61.9	60.8	38.3	46.32
T ₄	23.1	35.8	27.3	47.6	48.4	59.3	59.3	58.7	38.1	44.01
Mean	24.08	37.08	28.60	49.08	50.35	60.83	60.83	60.38	38.53	-

CD at 5% = Season (A) = 2.41; Treatment (B) = 1.60

Table 9.15. Effect of time of application of fertilizer on Zn (ppm) content of leaves of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	9.8	10.2	11.8	12.6	13.1	14.6	14.3	14.7	13.6	12.74
T ₂	11.3	11.9	12.3	12.8	13.9	14.1	13.7	14.5	13.6	13.12
T ₃	11.5	12.1	12.6	13.6	14.1	14.3	13.7	14.1	13.4	13.27
T ₄	10.6	10.8	11.2	12.2	12.7	13.6	13.1	13.2	11.9	12.14
Mean	10.80	11.25	11.98	12.80	13.45	14.15	13.70	14.13	13.13	-

CD at 5% = Season (A) = 1.46; Treatment (B) = 1.30

Table 9.16. Effect of time of application of fertilizer on Zn (ppm) content of leaves of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	10.3	10.7	10.9	11.6	12.8	13.6	13.3	14.2	14.1	12.39
T ₂	12.6	12.9	13.3	13.5	13.9	14.7	14.2	14.6	14.2	13.77
T ₃	12.9	13.6	14.6	14.9	15.4	15.6	15.1	15.5	14.9	14.72
T ₄	11.1	12.2	12.8	12.9	13.1	13.3	13.0	13.9	12.6	12.77
Mean	11.73	12.35	12.90	13.23	13.80	14.30	13.90	14.55	13.95	-

CD at 5% = Season (A) = 1.61; Treatment (B) = 1.40

Table 9.17. Effect of time of application of fertilizer on Cu (ppm) content of leaves of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	6.7	6.9	7.1	7.2	7.9	8.0	8.2	9.5	8.4	7.77
T ₂	7.1	7.3	7.3	7.6	8.2	8.4	8.7	9.8	8.7	8.12
T ₃	7.3	7.7	7.9	8.3	8.5	8.6	9.1	10.3	9.6	8.59
T ₄	6.9	6.9	7.5	7.9	7.9	8.1	8.5	8.9	7.8	7.82
Mean	7.00	7.20	7.45	7.75	8.13	8.28	8.63	9.63	8.63	-

CD at 5% = Season (A) = 0.37; Treatment (B) = 0.25

Table 9.18. Effect of time of application of fertilizer on Cu (ppm) content of leaves of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	7.3	7.6	7.8	7.9	8.0	8.2	8.6	9.2	8.7	8.14
T ₂	7.7	7.9	8.2	8.5	9.1	9.4	9.7	9.9	8.8	8.80
T ₃	7.9	8.0	8.8	9.2	9.7	9.8	10.2	10.5	9.6	9.30
T ₄	7.4	7.9	8.3	8.7	8.9	9.3	9.9	10.2	9.1	8.86
Mean	7.58	7.85	8.28	8.58	8.93	9.18	9.60	9.95	9.05	-

CD at 5% = Season (A) = 0.45; Treatment (B) = 0.30

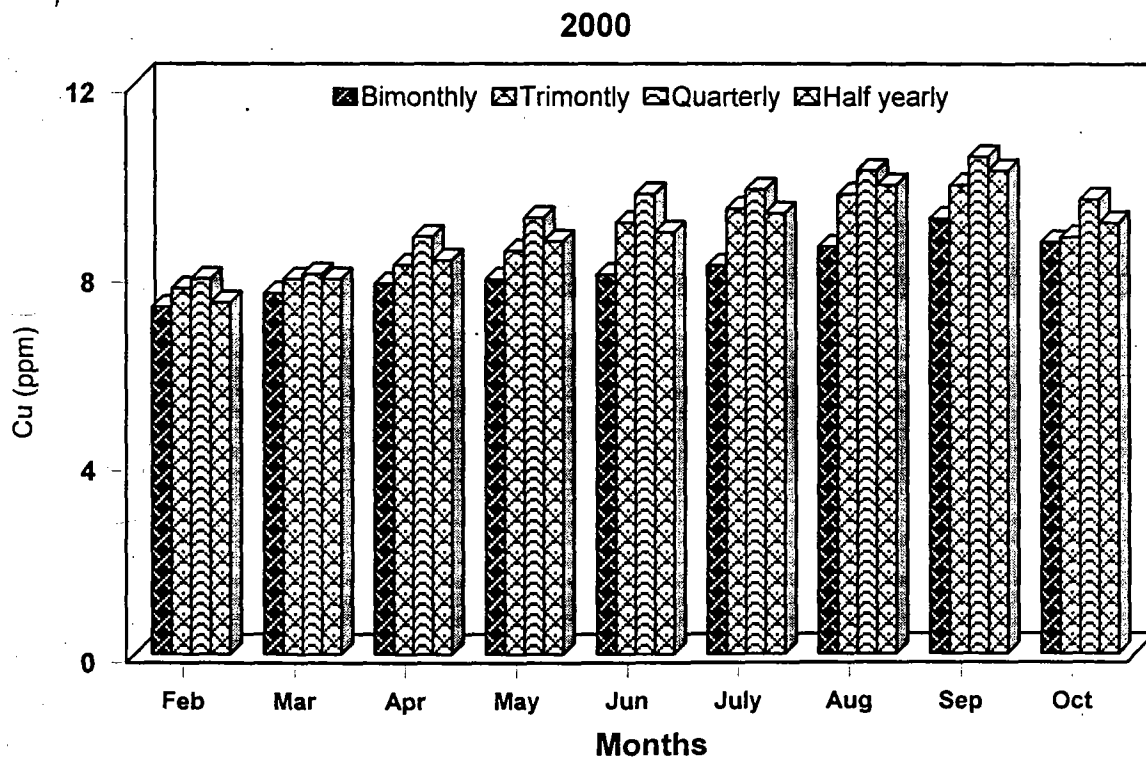
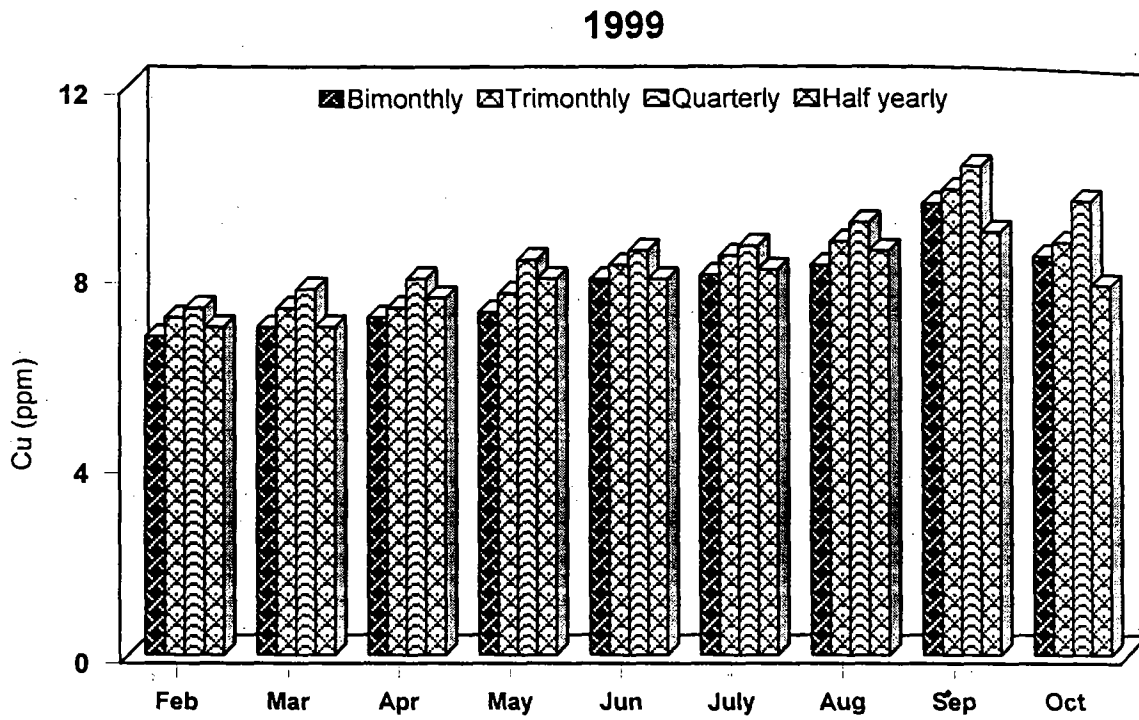


Fig. 14. Effect of time of application of fertilizer on leaf Cu (ppm) content

Table 9.19. Effect of time of application of fertilizer on Fe (ppm) content of leaves of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	93.2	107.8	76.6	109.9	100.8	103.4	110.3	117.4	105.6	102.78
T ₂	76.3	85.6	63.2	98.3	93.2	96.3	108.2	120.8	115.2	95.23
T ₃	91.7	109.3	84.5	123.6	120.4	121.6	130.4	136.8	123.1	115.71
T ₄	88.5	101.2	79.9	102.6	101.2	104.8	121.3	127.5	119.7	105.19
Mean	87.43	100.98	76.05	108.60	103.90	106.53	117.55	125.63	115.90	-

CD at 5% = Season (A) = 4.89; Treatment (B) = 3.26

Table 9.20. Effect of time of application of fertilizer on Fe (ppm) content of leaves of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	100.4	111.3	96.2	107.7	104.8	113.4	121.6	126.7	109.3	110.16
T ₂	98.3	102.4	91.6	99.5	92.4	99.4	105.3	117.6	112.3	102.09
T ₃	112.4	121.3	112.5	122.2	119.8	123.2	135.5	140.2	126.4	123.72
T ₄	99.6	104.3	94.2	113.1	100.9	112.6	128.4	132.1	120.8	111.78
Mean	102.68	109.83	98.63	110.63	104.48	112.15	122.70	129.15	117.20	-

CD at 5% = Season (A) = 4.56; Treatment (B) = 3.04

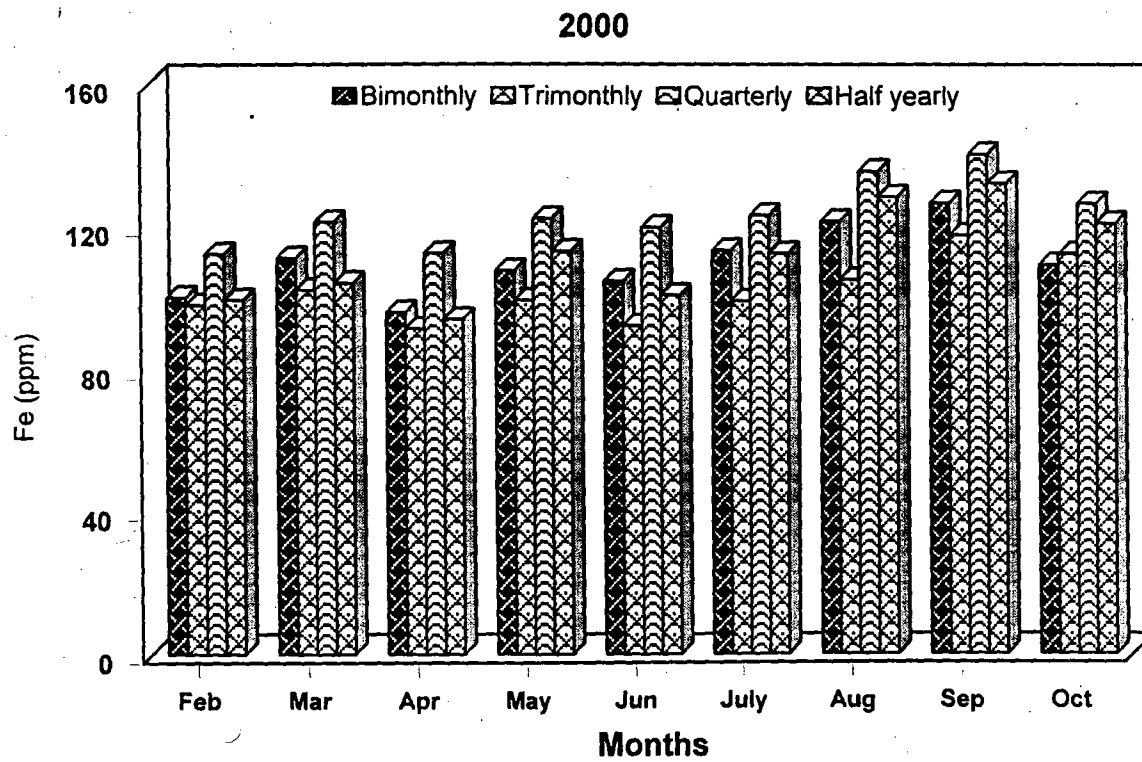
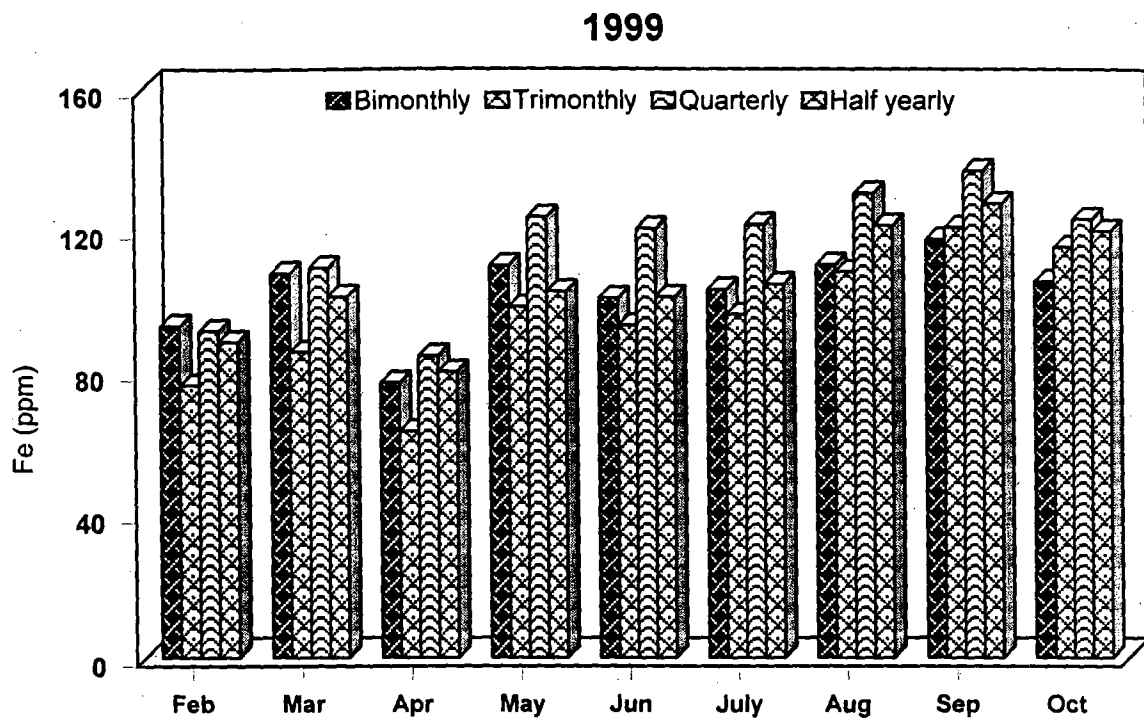


Fig. 15. Effect of time of application of fertilizer on leaf Fe (ppm) content

values throughout the stabilization period i.e. May to October on both the years (Tables No. 9.15 and 9.16).

During both the years, only T₃ has shown higher mean Cu values than rest of the treatments which has been followed by T₂ and T₄ in first year and T₄ and T₂ in second year. During peak period also only T₃ has produced higher values followed by T₂ and T₄ in first year and T₄ and T₂ in second year (Tables No. 9.17; 9.18 and Fig.14).

During peak period as well as stabilization period only T₃ has produced higher Fe values than other treatments which has reflected in mean value also. The next best result has been produced by T₄ followed by T₁ and T₂ (Table No. 9.19; 9.20 and Fig.15).

4. 7 Effect of Method of application of N on leaf nutrient status

4.7.1. Effect on leaf primary nutrients

The method of application experiment on leaf N content has revealed that T₂ is superior than the rest of the treatments on both the years. Even during stabilization period it has shown superiority all through July to October. There has been a ambiguity for next best treatment as T₃ has appeared best in first year and T₄ in second year. However during stabilization period T₄ in both years consistently proved numerical superiority to T₃. T₁ has been found to produce lowest mean values on both the years (Tables No. 10.1;10.2 and Fig.16).

Table 10.1. Effect of method of application of fertilizers on leaf N (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	2.23	2.37	2.56	1.82	1.79	2.74	2.78	2.62	2.36	2.363
T ₂	2.31	2.36	2.60	1.96	1.92	2.89	2.96	3.02	2.51	2.503
T ₃	2.28	2.40	2.58	2.02	1.86	2.73	2.81	2.73	2.34	2.417
T ₄	2.24	2.36	2.61	1.69	1.63	2.79	2.83	2.69	2.48	2.369
Mean	2.265	2.373	2.587	1.873	1.800	2.788	2.845	2.765	2.423	-

CD at 5% = Season (A) = 0.111; Treatment (B) = 0.074

Table 10.2. Effect of method of application of fertilizers on leaf N (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	2.30	2.34	2.51	1.78	1.78	1.81	2.79	2.81	2.64	2.378
T ₂	2.36	2.38	2.64	1.97	1.97	1.91	2.92	2.95	3.28	2.573
T ₃	2.21	2.423	2.56	1.98	1.99	1.87	2.72	2.83	2.70	2.409
T ₄	2.29	2.36	2.61	1.72	1.72	1.79	2.85	2.89	2.98	2.458
Mean	2.290	2.375	2.580	1.863	1.863	1.845	2.820	2.870	2.900	-

CD at 5% = Season (A) = 0.135; Treatment (B) = 0.090

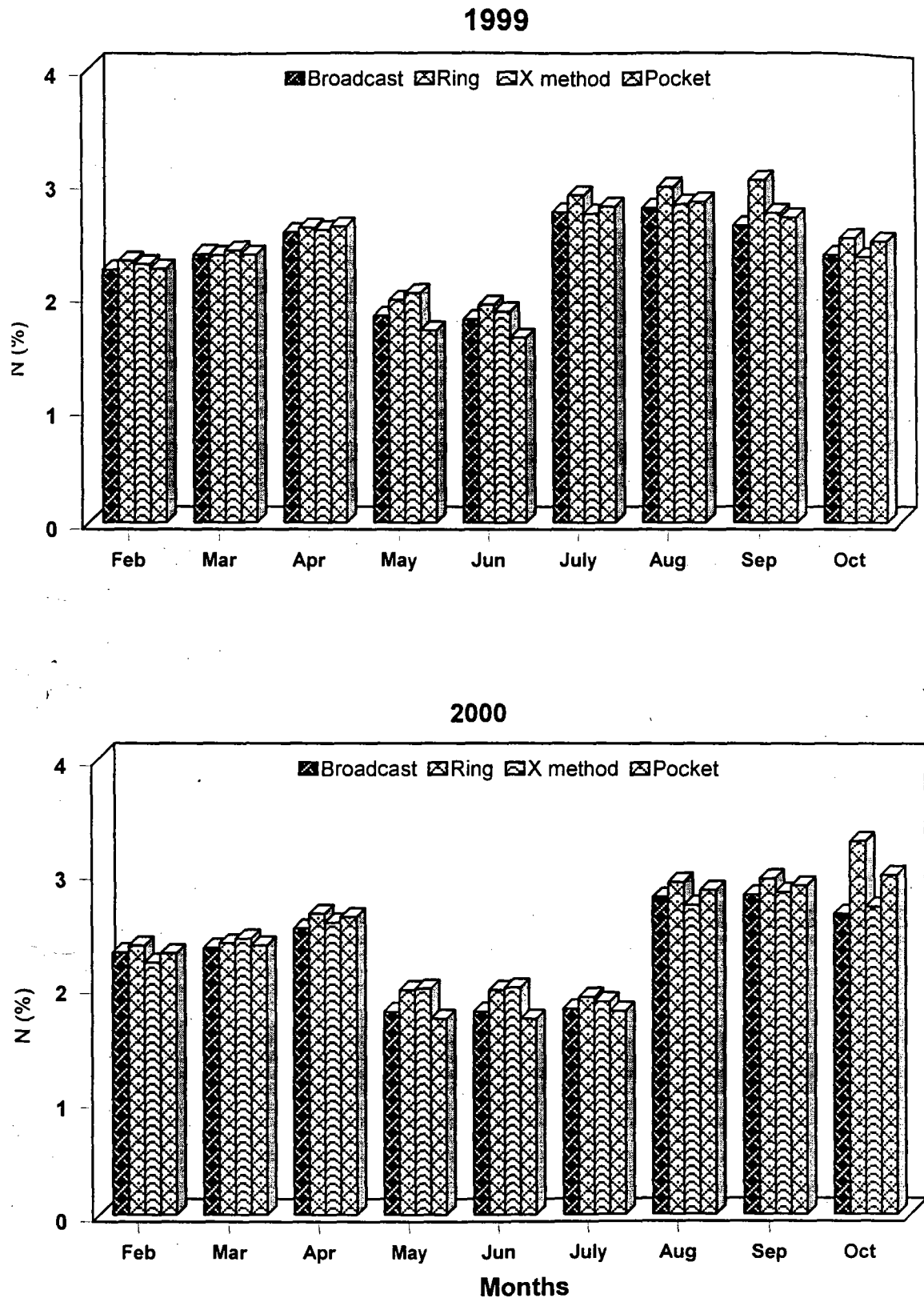


Fig. 16. Effect of method of application of fertilizer on leaf N (%).

Table 10.3. Effect of method of application of fertilizers on leaf P (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.18	0.23	0.22	0.15	0.13	0.21	0.19	0.23	0.27	0.201
T ₂	0.16	0.21	0.22	0.13	0.12	0.20	0.17	0.21	0.24	0.184
T ₃	0.18	0.29	0.25	0.16	0.14	0.17	0.17	0.21	0.22	0.199
T ₄	0.19	0.25	0.24	0.15	0.12	0.19	0.18	0.21	0.24	0.197
Mean	0.178	0.245	0.233	0.147	0.128	0.193	0.178	0.215	0.243	-

CD at 5% = Season (A) = 0.020; Treatment (B) = 0.011

Table 10.4. Effect of method of application of fertilizers on leaf P (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.18	0.24	0.22	0.16	0.12	0.23	0.22	0.23	0.25	0.206
T ₂	0.19	0.25	0.24	0.18	0.13	0.24	0.20	0.21	0.23	0.208
T ₃	0.16	0.20	0.19	0.16	0.11	0.20	0.19	0.19	0.21	0.178
T ₄	0.15	0.19	0.19	0.15	0.12	0.23	0.20	0.21	0.23	0.186
Mean	0.170	0.220	0.210	0.163	0.120	0.225	0.202	0.210	0.230	-

CD at 5% = Season (A) = 0.023; Treatment (B) = 0.013

Table 10.5. Effect of method of application of fertilizers on leaf K (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	1.46	1.60	1.64	1.25	1.21	1.67	1.73	1.79	1.84	1.577
T ₂	1.48	1.38	1.48	1.35	1.31	1.70	1.75	1.80	1.83	1.453
T ₃	1.50	1.57	1.58	1.29	1.30	1.62	1.69	1.73	1.79	1.452
T ₄	1.53	1.59	1.59	1.36	1.33	1.73	1.77	1.81	1.85	1.507
Mean	0.993	1.535	157.3	1.313	1.287	1.680	1.735	1.782	1.827	-

CD at 5% = Season (A) = 0.114; Treatment (B) = 0.76

Table 10.6. Effect of method of application of fertilizers on leaf K (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	1.54	1.63	1.64	1.34	1.27	1.64	1.71	1.79	1.81	1.597
T ₂	1.46	1.52	1.55	1.31	1.28	1.58	1.68	1.75	1.77	1.544
T ₃	1.51	1.52	1.53	1.35	1.30	1.68	1.72	1.78	1.79	1.576
T ₄	1.53	1.61	1.63	1.35	1.31	1.70	1.74	1.80	1.82	1.610
Mean	1.510	1.570	1.588	1.338	1.290	1.650	1.713	1.780	1.798	-

CD at 5% = Season (A) = 0.097; Treatment (B) = 0.065

Table 10.7. Effect of method of application of fertilizers on leaf Ca (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	3.61	3.72	3.84	3.94	4.14	4.31	4.36	4.54	4.62	4.120
T ₂	3.71	3.74	3.79	4.04	4.25	4.36	4.41	4.57	4.75	4.177
T ₃	3.70	3.73	3.81	3.97	4.11	4.37	4.48	4.53	4.69	4.154
T ₄	3.67	3.69	3.75	3.99	4.17	4.36	4.43	4.51	4.67	4.138
Mean	3.673	3.720	3.798	3.985	4.168	4.350	4.420	4.538	4.675	-

CD at 5% = Season (A) = 0.264; Treatment (B) = 0.176

Table 10.8. Effect of method of application of fertilizers on leaf Ca (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	3.58	3.70	3.81	3.94	4.15	4.29	4.32	4.51	4.61	4.101
T ₂	3.66	3.75	3.76	4.05	4.21	4.31	4.40	4.56	4.70	4.156
T ₃	3.64	3.72	3.79	3.95	4.09	4.35	4.43	4.53	4.65	4.128
T ₄	3.61	3.65	3.72	3.92	4.12	4.31	4.42	4.51	4.69	4.106
Mean	3.623	3.705	3.770	3.965	4.143	4.315	4.393	4.528	4.663	-

CD at 5% = Season (A) = 0.286; Treatment (B) = 0.190

Table 10.9. Effect of method of application of fertilizers on leaf Mg (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.51	0.45	0.40	0.33	0.35	0.38	0.42	0.44	0.40	0.409
T ₂	0.55	0.49	0.43	0.39	0.35	0.40	0.42	0.43	0.41	0.430
T ₃	0.57	0.50	0.42	0.37	0.36	0.38	0.41	0.43	0.41	0.428
T ₄	0.55	0.46	0.41	0.39	0.36	0.38	0.41	0.43	0.41	0.422
Mean	0.545	0.475	0.415	0.370	0.355	0.385	0.415	0.432	0.408	-

CD at 5% = Season (A) = 0.030; Treatment (B) = 0.020

Table 10.10. Effect of method of application of fertilizers on leaf Mg (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.54	0.41	0.39	0.31	0.33	0.36	0.42	0.43	0.41	0.400
T ₂	0.55	0.47	0.42	0.38	0.36	0.38	0.44	0.45	0.43	0.433
T ₃	0.59	0.48	0.42	0.38	0.36	0.39	0.40	0.44	0.42	0.431
T ₄	0.56	0.46	0.40	0.40	0.38	0.41	0.43	0.44	0.43	0.434
Mean	0.560	0.455	0.413	0.367	0.357	0.385	0.423	0.440	0.423	-

CD at 5% = Season (A) = 0.030; Treatment (B) = 0.020

Table 10.11. Effect of method of application of fertilizers on leaf S (%) of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.17	0.29	0.36	0.39	0.33	0.32	0.39	0.34	0.31	0.322
T ₂	0.31	0.33	0.39	0.42	0.39	0.34	0.40	0.37	0.34	0.366
T ₃	0.24	0.31	0.36	0.40	0.35	0.35	0.39	0.35	0.31	0.340
T ₄	0.28	0.31	0.38	0.42	0.37	0.32	0.37	0.34	0.32	0.346
Mean	0.250	0.310	0.372	0.407	0.360	0.333	0.388	0.350	0.320	-

CD at 5% = Season (A) = 0.022; Treatment (B) = 0.015

Table 10.12. Effect of method of application of fertilizers on leaf S (%) of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	0.19	0.30	0.35	0.37	0.32	0.31	0.38	0.35	0.30	0.319
T ₂	0.30	0.31	0.36	0.39	0.36	0.31	0.34	0.35	0.32	0.338
T ₃	0.27	0.32	0.39	0.41	0.38	0.36	0.38	0.31	0.29	0.346
T ₄	0.28	0.29	0.38	0.44	0.40	0.34	0.35	0.30	0.28	0.340
Mean	0.260	0.305	0.370	0.403	0.365	0.330	0.362	0.327	0.298	-

CD at 5% = Season (A) = 0.024; Treatment (B) = 0.016

Mean P values has shown a confusing trend. During first year T₁, T₃ and T₄ have shown higher values which have been found to be at par. However, during second year T₂ and T₁ have been found to be superior. But when values are compared during stabilization period of July to October it has been found that T₁ is constantly superior (Tables No. 10.3 and 10.4).

Like P, K also has revealed a preplexed trend in mean values. In first year T₁ and T₄ have shown superiority. But in second year in addition to those two treatments T₃ also have produced higher values. However when values during stabilization period of July to October are compared and all the treatments have been found to be at par (Tables No. 10.5 and 10.6).

4.7.2 Effect on leaf secondary nutrients

Method of application has not affected the calcium values as it has been found to be at par for all the treatments both their mean values and their values during stabilization period of July to October (Tables No. 10.7 and 10.8).

The mean Mg values have revealed that except T₁ all other treatments have proved superior and are at par. However during stabilization period of August to October all the treatments have been found to be at par (Tables No. 10.9 and 10.10).

The method of application has produced highly muddled trend in case of S. On both years only T₂ has produced consistently higher values though on second year T₃ and T₄ have also produced higher values which have been found

Table 10.13. Effect of method of application of fertilizers on Mn (ppm) content of leaves of Kinnow during -1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	23.4	30.4	27.4	49.2	40.0	53.2	57.8	50.2	33.2	40.53
T ₂	25.1	33.4	29.6	56.1	41.3	61.3	65.7	59.4	41.9	46.18
T ₃	23.0	31.2	27.5	54.1	43.8	61.4	63.9	60.1	35.6	44.51
T ₄	23.6	35.1	28.2	49.8	41.3	60.2	63.2	49.9	35.2	42.94
Mean	23.78	32.53	28.18	52.30	41.60	59.48	62.66	54.90	36.48	-

CD at 5% = Season (A) = 2.66; Treatment (B) = 3.78

Table 10.14. Effect of method of application of fertilizers on Mn (ppm) content of leaves of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	24.1	33.4	28.2	50.2	41.4	53.9	61.1	53.2	35.1	42.28
T ₂	25.6	34.1	28.2	55.1	40.3	61.2	64.2	58.1	40.3	45.23
T ₃	25.4	33.4	29.1	54.9	44.3	62.4	63.9	59.4	33.1	45.10
T ₄	23.2	34.2	28.6	49.9	44.3	60.4	63.1	55.4	36.9	44.00
Mean	24.58	33.78	28.53	52.53	42.58	59.58	63.08	56.53	36.35	-

CD at 5% = Season (A) = 3.82; Treatment (B) = 2.15

Table 10.15. Effect of method of application of fertilizers on Zn (ppm) content of leaves of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	11.3	12.3	12.9	13.9	14.1	14.4	13.8	14.2	13.8	13.41
T ₂	10.9	11.4	12.3	12.8	13.4	14.5	14.4	13.9	13.9	13.06
T ₃	11.4	12.3	12.8	13.6	14.4	14.3	13.9	13.6	13.3	13.29
T ₄	12.1	12.9	13.1	13.9	14.3	14.4	14.0	13.8	13.2	13.52
Mean	11.43	12.23	12.78	13.55	14.05	14.40	14.03	13.88	13.55	-

CD at 5% = Season (A) = 0.85; Treatment (B) = 0.56

Table 10.16. Effect of method of application of fertilizers on Zn (ppm) content of leaves of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	11.8	12.5	13.1	13.8	14.2	14.5	13.6	14.2	13.6	13.48
T ₂	12.1	12.4	12.4	13.1	13.6	14.7	14.3	13.7	13.6	13.32
T ₃	11.8	12.2	12.8	13.6	14.2	14.0	13.8	13.8	13.4	13.29
T ₄	11.7	12.8	13.2	13.7	14.2	14.6	14.2	13.3	12.3	13.44
Mean	11.85	12.48	12.88	13.55	14.05	14.45	13.98	13.75	13.48	-

CD at 5% = Season (A) = 0.98; Treatment (B) = 0.65

Table 10.17. Effect of method of application of fertilizer on Cu (ppm) content of leaves of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	7.6	7.9	7.9	8.3	8.5	8.6	9.6	10.9	9.7	8.78
T ₂	7.4	7.8	8.3	8.3	8.8	8.9	9.7	11.2	9.5	8.88
T ₃	7.9	8.2	8.3	8.5	8.6	8.8	9.6	11.2	9.1	8.97
T ₄	7.3	7.7	7.9	8.3	8.5	8.9	10.3	11.1	9.8	8.87
Mean	7.55	7.90	8.10	8.35	8.60	8.80	9.80	11.10	9.53	-

CD at 5% = Season (A) = 0.57; Treatment (B) = 0.38

Table 10.18. Effect of method of application of fertilizer on Cu (ppm) content of leaves of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	7.3	7.8	7.9	8.2	8.4	8.6	9.3	10.4	9.6	8.61
T ₂	7.4	7.8	8.1	8.3	8.6	8.7	9.5	11.1	9.3	8.76
T ₃	7.6	7.7	8.0	8.4	8.6	8.6	9.1	10.9	9.4	8.70
T ₄	6.9	7.2	7.7	8.2	8.6	8.8	9.3	10.3	9.4	8.49
Mean	7.30	7.63	7.93	8.28	8.55	8.68	9.30	10.68	9.43	-

CD at 5% = Season (A) = 0.60; Treatment (B) = 0.40

Table 10.19. Effect of method of application of fertilizer on Fe (ppm) content of leaves of Kinnow during 1999

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	100.3	110.2	79.6	130.2	120.8	121.8	133.6	136.4	120.4	117.03
T ₂	104.2	120.1	83.2	100.4	113.2	131.8	140.3	143.2	131.4	118.64
T ₃	107.4	121.3	80.4	121.3	120.4	124.4	135.6	138.8	121.5	119.01
T ₄	98.2	110.6	81.6	113.4	127.6	130.4	136.7	138.5	127.8	118.31
Mean	102.53	115.55	81.20	116.33	120.50	127.10	136.55	139.23	125.28	-

CD at 5% = Season (A) = 7.76; Treatment (B) = 5.17

Table 10.20. Effect of method of application of fertilizer on Fe (ppm) content of leaves of Kinnow during 2000

Treatments	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
T ₁	99.3	113.2	83.5	125.6	124.2	126.4	130.6	136.4	124.6	118.31
T ₂	107.3	122.6	85.4	104.4	117.4	129.3	138.2	141.1	130.8	116.68
T ₃	107.6	121.4	81.3	121.3	120.8	127.3	137.3	139.4	120.8	119.74
T ₄	99.4	109.4	78.7	104.9	125.3	130.4	135.6	139.4	123.4	114.22
Mean	103.40	116.65	82.23	114.05	114.10	121.93	128.35	135.43	139.08	-

CD at 5% = Season (A) = 8.86; Treatment (B) = 5.91

to be at par with T₂. None of the treatments have shown a stabilizing values during stabilization period (Tables No. 10.11 and 10.12).

4.7.3 Effect on leaf micronutrients

Mean leaf Mn value as well as values during stabilization period shown that T₂, T₃ and T₄ are superior and are at par. Mean value as well as values during stabilization period have revealed that method of application has no effect on leaf Zn content. All the treatment values from June to October have been found to be at par. Similar trend has been produced in Cu also. All the treatments have been found to be at par. Mean Fe content on leaves also have shown that all the treatments are at par. The values during stabilization period of May to October have revealed that there is not much difference between the treatments except T₁ in first year. However, in second year even T₁ also has produced values similar to other treatments (Tables No. 10.13 to 10.20).

5. DISCUSSION

The experiments to standardize sampling techniques for tissue nutrient analysis and on varying doses of fertilizers and their method and time of application in Kinnow were conducted in farmer's orchard at Farukh Nagar, Gurgaon, Haryana. The tissue and quality analysis was carried out at Tissue Nutrient Laboratory, National Professor Scheme, Division of Fruits and Horticultural Technology, IARI, New Delhi.

In the recent past some attempts have been made to determine the nutritional requirement of Kinnow by analysing leaf tissues. However, a holistic approach was needed to determine the sampling techniques and to decide the fertilizer requirement of Kinnow. The present study was conducted with this long term objective in view and the results obtained are discussed here.

5.1. Effect of sampling technique on leaf nutrient status

5.1.1. Effect of time of sampling on leaf nutrient status

From the experimental study on the effect of time of sampling on leaf nutrient status of Kinnow, it was found that stabilization period for all the ten nutrients analyzed occurred more or less between June to October, i.e., in spring flush. Though stabilization of values of all nutrients except Mn occurred

during autumn flush, i.e., between February to April, the leaf nutrient values did neither attain maxima nor optima. The maximal values or optimal values were observed only in the spring flush. The reason for attainment of maximum values in spring flush is due to the fact that the period before the emergence of spring flush, i.e., in summer soil the moisture stress coupled with high evaporation demand makes the plant roots go deeper in search of water (Singh *et al.*, 1990). This extended root penetration gives new areas in soil for nutrient absorption. Further the rainfall during spring flush emergence makes the absorption easier for Kinnow plants. This, in turn, is expressed in the plants as higher leaf nutrient values.

From this present study, it has been concluded that spring flush can be taken for nutrient analysis of Kinnow. This results were found to be in accordance with that of Nijjar and Brar (1977) who collected leaf samples in Kinnow from June onwards. Similar studies by Dixit *et al.* (1979), Iyengar *et al.* (1982) in mandarin orange and Chanana and Nijjar (1984) in sweet orange and Sharma and Mahajan (1990) also proved spring flush as the best stage for nutrient analysis.

From the spring flush, August was found to be the best month for leaf sampling.

5.1.2. Effect of position of leaves on leaf nutrient status

For all nutrients other than Ca, collection of leaves from terminal position of non-fruiting terminal (T_1) was found to be superior. This indicates

that all the nutrients are affected by the position of sampling which is in contrast to the report of Nacha Gowda *et al.* (1985) who reported that only K and Ca were affected by zone of leaf sampling. Nevertheless, in present study the Ca content has been found to be low in T₁ and high in T₂ (middle position of non fruiting terminal). This may be due to the low mobility of Ca inside the plant (Salisbury and Ross, 1986).

Hence, the present study, shows that for better results, the leaf samples in Kinnow can be collected from terminal position of non-fruiting terminals for all nutrients analysis except Ca. Same kind of results have been obtained by Chitkara and Bhambota, (1971), Bhutani *et al.* (1978), Mann and Sandhu (1983) and Chundawat *et al.* (1991). For Ca alone leaves from middle position of non-fruiting terminal can be collected. Similar results were reported by Koo and Sites (1956) and Martin Prevel (1966).

5.1.3. Effect of sample size on leaf nutrient status

The present study, revealed that sample size does not have any effect on the N, P, K, Ca, Mg, Mn, Zn, Cu and Fe content of the leaves. However, when the values of stabilization period (July-September) are compared, only N, Ca, Mg and Zn was found to produce the values which were found to be at par for all the treatments. During the same period though it was observed, in P, S and Fe, the treatment values were different, they did not produced consistent values for both the years. This makes it difficult to draw any definite conclusion. Nevertheless, for K and Mn, during stabilization period, T₃ and T₄ were found

to be superior and at par. For the same period T₃ was found to be superior for leaf Mn content.

These results indicate that though mean values have not differed for all the nutrients analysed save S, the values during stabilization period differed at least for K, Mn and Cu. In these elements, higher amount of sample size was found to represent the optimum leaf content of these elements. Though in K and Mn, T₃ and T₄ ((70 and 90 leaves/tree) were found to be superior, collection of 70 leaves/tree will be a better option, for all the elements. Though, this result contradicts the previous reports of Sharma and Mahajan (1990) who collected 5 leaves/tree in mandarin, Mustaffa (1989) who has collected 20 leaves/tree in Coorg mandarin and Singh and Kunwar (1982) who collected 30 leaves/tree in sweet orange, it has been found to be in corroboration with results of Iyengar *et al.* (1982) who suggested higher sample size i.e. 100 leaves/tree in Coorg Mandarin and Kinnow.

5.1.4 Effect of aspect of tree on leaf nutrient status

5.1.4.1 Effect on leaf primary nutrients

Mean nitrogen content in leaves did not show any difference. Even during stabilization period of July to September only during July a significant difference was found between T₃ and T₄ and T₁ and T₂. The reason for the difference was due to the fact that light intensity on these sides *viz.*, east and west might have caused more vegetative growth (Krishnamoorthy, 1993) which in turn might have influenced the translocation of more nitrogen on these sides.

The mean P value has shown that only T₂ produced lower values. During the stabilization period between July to September, the trend was found to be confusing. Nevertheless, numerically higher mean values were found in T₃ and T₄. This again can be best explained by the light intensity theory as mentioned by Krishnamoorthy (1993).

Though the mean K content showed that all the treatments were at par, here again T₃ and T₄ have shown their numerical superiority over T₁ and T₂. During stabilization period also the same trend continued. This phenomenon also can be explained by the light intensity theory as mentioned by Krishnamoorthy (1993).

5.1.4.2 Effect on leaf secondary nutrients

In Ca no difference was noticed either in stabilization period values or in mean Ca values. This is in conformity with the reports of Dixit *et al.* (1979) and Mann and Sandhu (1983) who also collected samples all around the tree.

The mean Mg values showed that all the treatments were at par and the values during stabilization period have revealed that T₃ and T₄ were superior over T₁ and T₂. This indicated that east and west directions are best suitable for Mg analysis. This contradicts the reports of Mann and Sandhu (1983) who recommended collection of leaves all round the tree. Nevertheless, the results obtained in the present study can be better explained by the fact that the leaf N and Mg has a positive interaction as both of the them are constituents of

chlorophyll. Hence, availability of sunlight in east and western sides increases the chlorophyll, which in turn increases Mg uptake.

T₃ and T₄ showed consistently higher mean S values than other treatments. During stabilization period also, T₄ and T₃ were found to be superior. This indicates that leaves from east and west directions are best for S analysis. This finding contradicts with the earlier report by Dixit *et al.* (1979) and Mann and Sandhu (1983) and confirms the report of Basso *et al.* (1993) who stated that N has positive interaction with S which may be the reason for higher S content in east and west directions.

5.1.4.3 Effect on leaf micronutrients

Though mean leaf Mn content was on par in all the treatments, the Mn value during stabilization period suggests that T₃ and T₄ were superior over T₁ and T₂. This again fits into the light intensity theory as mentioned by Krishnamoorthy (1993).

The mean Zn values revealed that T₃ and T₄ are numerically inferior to T₁ and T₂. This may be because of enhanced translocation of phosphorus in east and west direction influenced by light, which might have reduced the translocation of Zn on these sides resulting in phosphorus, induced Zn deficiency (Kalyanasundaram and Mehta, 1970).

The mean Cu content in leaves revealed that T₁ and T₂ were numerically superior to T₃ and T₄. This indicates that, for Cu analysis north and south directions may be better. On the other hand, though T₃ and T₄ showed

numerical inferiority, they have been found to statistically at par with T₁ and T₂. Their numerical inferiority can be better explained by the negative interaction between translocation of P and Cu (Bingham and Garber, 1960). As in east and west directions there might have been more amount of P translocation, which in turn might have influenced the Cu translocation to a maximum degree in a negative way.

In mean Fe content also T₁ and T₂ were found to be numerically superior. This trend can also be explained by the P interference with movement and metabolic functioning of Fe (Price, 1968).

From this, it can be concluded that though for all the nutrients, save P and S the mean values were found to be statistically uniform for all the treatments. Based on numerical superiority, either in their leaf mean values or the values of stabilization period, leaf samples can be collected from east and west directions for N, K, Ca, Mg and Mn and from north and south directions for Zn, Cu and Fe. Since, for these elements, mean values were found to be at par for all directions. It can thus be recommended that leaf samples can be collected from any or all directions. Nevertheless, for analysis of P and S it should be collected from east and west directions, as these directions proved to be significantly superior to north and south directions.

5.2 Effect of varying doses of N on leaf nutrient status, yield and quality

5.2.1 Effect on leaf primary nutrients

Increase in application of N increased leaf N content as a whole. The highest leaf N content was recorded in T₇, followed by T₆ and T₅.

However, leaf N stabilised during July to September only in T₅. These results are in conformity with the results of Huchche *et al.* (1996) and Singh (1998) who recommended maximum of 800 g of N/tree/year for citrus. Similar results were obtained by Koo *et al.* (1974) in lemon, who have stated that application of 650 to 935 g of N/tree/year brought the leaf nitrogen content to optimum level.

Increase in application of N increased the mean leaf P content. Highest leaf P content was recorded in T₇ followed by T₆ and T₅. All these three treatments were found to be at par. This may be due to the positive interaction between N and P in plants (Wallace,1990).

The mean leaf K content revealed that increase in application of N increased K content upto certain level of application i.e. T₅ after which it showed a negative interaction with K. This may be due to the fact that at higher level of N application, the uptake of K tends to be less. Similar reports were have been made by Koo *et al.* (1974) in lemon and in Kinnow by Shahkhyan and Bhardwaj (1989).

5.2.2 Effect on leaf secondary nutrients

The leaf Ca content was not affected by increasing level of N application which was revealed by the mean Ca content in leaves. All the treatments including control were found to be at par. Similar results were reported by Bhutani *et al.* (1978).

Higher doses of N increased the leaf Mg content in leaves. This trend was more evident during stabilization period especially in the second year. This result has been found to corroborate with the results of Koo *et al.* (1974).

Leaf S content produced a uniform trend for every incremental application of N. All the treatments were found to be at par. In the second year T₆ and T₇ produced numerically higher values than T₅. The trend in leaf S content indicates that application of N did not affect this. This is in conformity with the report made by Baruah (1997).

5.2.3. Effect on leaf micronutrients

Leaf Mn content showed that it increased with increase in application of N. The maximum numerical value was recorded at T₇ level. However, T₅, T₆ and T₇ were found to be at par. This trend indicates that applied N and leaf Mn have a positive interaction. This result was found to contradict the result of Mann and Sandhu (1983) who reported that the N has no effect on Mn. Nevertheless, the positive interaction between N and Mn found in the present study was due to the fact that N being the constituent of chlorophyll may increase the photosynthetic rate, which in turn requires photo oxidation of water molecule. For photo oxidation of water Mn protein is needed. This requirement of Mn protein may induce the uptake of Mn.

Though the mean Zn values produced were uniform between T₃ to T₇, T₇ recorded numerically higher values. This indicates a positive interaction

between N and Zn. This result is in corroboration with reports of Langin *et al.* (1962).

Higher amount of application of N produced higher Cu values in leaf. Mann and Sandhu (1983) in their experiment also found the result of positive interaction between N and Cu.

Leaf Fe content increased upto T₅ level with every addition of N. It however decreased T₆ onwards. This indicates that N and Fe have positive interaction upto a certain level after which they have antagonistic effect. This may be due to the reason that higher amount of N may facilitate P uptake which in turn may reduce Fe translocation (Price, 1968).

5.2.4 Effect on yield and quality

The individual fruit weight and number of fruits per tree increased with increased amount of N fertilizer application. This shows a positive interaction between applied N and fruit yield in Kinnow. Similar results were obtained by Koo *et al.* (1974) and Sarooshi *et al.* (1991) in sweet oranges. Possible reason for this may be that N induces more amount of carbohydrate accumulation.

Juice percentage, TSS and acidity increased with application of N upto T₄ level and later these decreased. Similar trend was observed by Huchche *et al.* (1996). In their experiment with acid lime they obtained higher juice percentage, TSS and acidity at medium range (600 g/tree/year) than higher or lower (800 g and 200 g of N/tree/year), respectively.

5.3 Effect of varying doses of P on leaf nutrient content, yield and quality

5.3.1. Effect on leaf primary nutrients

Increased P application produced higher N content in leaves. Except T₁ all other treatments have produced statistically uniform values. Amongst treatments, during stabilization period T₃, T₄ and T₅ were found to be statistically at par. Nevertheless, T₄ proved its numerical superiority both in mean values and values of stabilization period. This indicates the leaf N values increased upto a certain level of P application and beyond this it started decreasing. This result contradicts the results obtained by Mustaffa (1989), Chundawat *et al.* (1991) and Lallan Ram *et al.* (1997) who suggested that applied P has no affect on leaf N. But the phenomenon obtained from the present study can be better explained by the point that applied P increases root growth. The extended root growth might have absorbed more N. However the root growth cannot be increased beyond certain level even with the application of P. At this point, the N absorption may become constant. The application of P beyond this level may lead to a situation in which more P may be available for absorption than N, which may lead to reduction in N absorption.

Increase of P application increased the leaf P content. Obviously T₅ produced highest values. Though in mean P values T₄ and T₅ were found to be at par; during stabilization period T₅ was found to be superior. Similar kind of results were observed by Bopaiah *et al.* (1982) in mandarin and Sarooshi *et al.* (1991) in sweet orange.

Increase in P application did not produce any traceable increase in leaf k content. In other words the P application had no effect on leaf K content. This finding is in corroboration with the findings of Lallan Ram *et al.* (1997).

5.3.2 Effect on leaf secondary nutrients

The mean leaf Ca values and the values during stabilization period were not affected by the increase in dose of P fertilizers. Bhutani *et al.* (1978) reported similar result in sweet orange.

The leaf Mg values increased with increasing levels of P application. The Mg values attained a peak in T₄ after which it started decreasing. Nevertheless, T₃, T₄ and T₅ were found to be statistically at par both at their mean values and during their stabilization period. Chundawat *et al.* (1991) in acid lime have shown that the Mg uptake as well as leaf nutrient content increased with the increased P application till certain level after which it decreased. The results obtained in the present study coincide with the above-mentioned report. It is possible that Mg uptake might have been influenced by uptake of N as both these elements are having positive interaction.

The leaf S content was not affected by application of P fertilizers. The applied P and leaf Mn showed a positive interaction. This may again be influenced by N as its application has a positive interaction with Mn interaction.

5.3.3 Effect on leaf micronutrients

The Zn content in leaves increased upto T₄ level of P application beyond which it started decreasing. This indicates that, upto certain critical level, P

may not interfere with Zn. Nevertheless, once this critical level is crossed, applied P may interact with Zn and may lead to phosphorous induced Zn deficiency (Kalyanasundaram and Mehta, 1970). At T₅ level, the applied P might have crossed the critical level which in turn can effect the leaf Zn content.

The same phenomenon was observed during the peak period in leaf Cu contents and during stabilization period in leaf Fe content. In this case also, after T₄ these nutrient contents in leaves started decreasing. Both of these element had a negative interaction with P. This was also reported by Bingham and Garber (1960) for Cu and Biddulph (1953), Watanbe *et al.* (1965) and Price (1968), for Fe.

5.3.4 Effect on yield and quality

Application of P increased both the yield parameters, i.e., individual fruit weight and number of fruits/tree. T₅ was found to be superior. However, T₄ was also found to be at par with T₅. Wallace (1990) reported that increase of P application increased the yield. In the present study also, similar kind of result has been observed.

Application of P increased TSS as well as acidity in fruits. Though fruits of T₅ had highest amount of TSS and acidity there in T₄ were also found to be at par. However, in case of juice percentage, though T₄ and T₅ were found to be at par, T₄ proved to be numerically superior. The increase in quality parameters may be due to increased root growth, better nutrient uptake

and higher nutrient content in leaves as shown in the present study. These factors might have influenced the yield and quality parameters to a positive level.

After considering the above mentioned results it can be concluded that T₄ (300 g/tree/year) and T₅ (500 g/tree/year) level of P application gave better results in leaf nutrient status of essential elements, yield and quality of fruits. Nevertheless, considering higher cost of fertilizers, T₄ level of P application would be advantageous.

5.4 Effect of varying doses of K on leaf nutrient status, yield and quality

5.4.1 Effect on leaf primary nutrients

The increase in application of K increased N content in leaves from T₁ level upto T₄ level. Thereafter, every incremental addition of K reduced the leaf N content. However, mean values of all the treatments were found to be at par. During stabilization period of July to September K doses at T₄ and T₅ level were found to be at par and superior to the rest of the treatments. The above mentioned results have shown a positive interaction between applied K and leaf N upto certain level. At higher level of K application, the positive interaction turned into a negative interaction. Negative interaction has earlier been supported by Koo *et al* (1974) and Shankhayan and Bhardwaj (1989). Nevertheless, the initial positive trend in the present study can be explained by the fact that the applied K might not have reached the critical limit to interfere negatively.

During stabilization period of September and October T₅ and T₄ have consistently proved superior in respect of leaf P content. This indicates a positive relationship between applied K and leaf P. Similar report was made by Wallace (1990) who stated that when primary nutrients are applied together, their individual response increased by 2-3 percent.

Increase in K application increased the K level in leaves with T₅ recording the highest value, T₄ was found to be at par with T₅. This kind of linear trend between applied K and leaf K has been reported by Koo *et al* (1974) in lemon, Koo (1988) in Shamouti orange, Shankhyan and Bhardwaj (1989) in Kinnow and Chundawat *et al.* (1991) in acid lime.

5.4.2 Effect on leaf secondary nutrients

Applied K, decreased leaf Ca level after T₅. Similar trend was observed in Mg level too. This indicates the existence of negative interaction between K in one hand and Ca and Mg on the other. Similar trend was observed by Shankhyan and Bhardwaj (1989) in Kinnow. There was a positive interaction between applied K and leaf S values. T₅ produced maximum S value followed by T₄.

5.4.3 Effect on leaf micronutrients

The leaf Mn and Zn content showed an initial positive trend till T₄ level after which it was found to be decreasing. This indicated a negative trend after attaining a critical K level. The initial positive trend has been reported earlier by Dixit *et al* (1979).

The leaf Cu showed a negative trend with the additional increase in K. Corresponding results were obtained by Dixit *et al.* (1979) and Mann and Sandhu (1983) who observed a negative trend between K and Cu.

The mean Fe values indicated that the application of K did not influence the leaf Fe content. Similar results were obtained by Mann and Sandhu (1983).

5.4.4 Effect on yield and quality

The application of K increased fruit weight, number of fruits/tree, juice percentage and TSS upto T₄ level after which it showed a diminishing trend. Similar results were observed by Shankhayan and Bhardwaj (1989) in Kinnow. The possible reason for this trend may be to increase in K, which leads to reduction in N uptake, and thus results in yield reduction. Moreover K application resulted in rind thickness leading to decrease in pulp of the fruit which may be responsible for reduction in juice content. The reduction in Mg uptake due to increase in K may hinder photosynthesis which may be responsible for reduction in TSS. The application of K increased the acidity. Similar results were reported by Bhardwaj and Shankhayan (1983).

5.5 Effect of time of application on leaf nutrient status

5.5.1 Effect on leaf primary nutrients

Significantly, superior mean N values were observed in T₁ and T₂ treatments. However, highest N values were observed during stabilization period in T₃. This indicates that though in mean values bimonthly and tri-monthly applications proved superior during stabilization period, it was

quarterly application which proved superior. These results were in line with those reported by Huchche *et al.* (1996) who recommended application of N 3 times in a year. The possible reason for the higher amount of N in leaf during stabilization period in quarterly application could be that the fertilizer application coincides with the active growth period of Kinnow i.e. February and June as well as reproductive growth period i.e. October.

The time of application proved decisive in P content of leaves during the first year amongst the mean values, T₁ was found to be superior while in the second year, T₃ proved superior. However, during stabilization period, T₃ was found consistently superior. This indicates that the leaf N and P have a positive interaction as reported by Lallan Ram *et al.* (1997).

The leaf K content showed a clear trend by producing significantly higher value in T₃ during stabilization period. This again indicated a positive trend between N and K as suggested by Lallan Ram *et al.* (1997).

5.5.2 Effect on leaf secondary nutrients

The mean Ca values were found to be at par for all treatments except T₁. However, during the stabilization period T₃ and T₄ found to be superior. After T₃ the values of Ca started decreasing, indicating a negative interaction beyond certain level of leaf N. This kind of negative trend has been earlier reported by Bopaiah *et al.* (1982). However if negative interaction existed between these two elements, then T₃ couldn't have emerged as a superior treatment. So the phenomenon exhibited by Ca in this case can be better explained by the fact

that Ca is a slow moving element. In case of T₃ and T₄, the application of N fertilizer before the stabilization period was June and July, respectively. On the other hand, it was August in case of T₁ and T₂. N being highly mobile element and having negative interaction with Ca could have affected the less mobile Ca uptake more in case of T₁ and T₂ than that in T₃ and T₄. Since N application in T₃ was one month earlier than T₄ it emerged as numerically superior treatment.

The mean Mg values indicated a positive trend with N by exhibiting higher values in T₁ and T₂. However during stabilization period T₁ and T₃ were found to produce values which are statistically at par. T₃ however, proved its numerical superiority. This again may be due to the positive interaction between N and Mg, which has been reported by Koo *et al.* (1974).

By producing consistent leaf S values, T₃ emerged as a better treatment. These results are in line with Basso *et al.* (1983) who have suggested leaf N and S have positive interaction.

5.5.3 Effect on leaf micronutrients

Consistent leaf Mn values have indicated that T₃ is the better treatment; even though T₁ also produced values which were found to be at par with T₃. The higher Mn during stabilization period in T₃ can be explained by the fact that higher N content in leaves of T₃ might have influenced uptake of Mn (Krishnamoorthy, 1993).

During the first year, even though mean Zn values of all treatment were at par only T₂ and T₃ produced similar results in the second year. Amongst

these only T₃ recorded consistently higher values throughout the stabilization period, on both the years. T₃ was found to have higher N during stabilization period which might have influenced the uptake of Zn as N and Zn has positive interaction which was reported by Mann and Sandhu (1983) in Kinnow.

Similarly mean leaf of Cu and Fe contents has revealed that T₃ is a superior treatment. This again shows a positive interaction existing between these elements and N quarterly application of N thus can be considered as a superior time of application as it increases not only N uptake but also the uptake of other nutrients also.

5.6 Effect of method of application

The method of application of N produced higher leaf N content in T₂. This may be due to the reduction of N fertilizer losses due to supply of fertilizer near to the feeder roots. This result is in corroboration with the reports made by Prasad *et al.* (1971), who suggested that placement of N 5.8 cm below the surface was a superior method of application.

The stabilization period values showed that T₁ was consistently superior for leaf P content. This indicates that broadcasting of N influenced positively the uptake of P. This may be as a result of production of more feeder roots on the subsurface layer as a result of broadcasting N. This increased feeder roots might be absorbing more P. Similar kind of results were reported by Nijjar and Brar (1977) in Kinnow as a result of Zn application. Moreover kinetic studies

made by Keshavamurthy (1996) also revealed that high inflow of P due to a greater number of absorption sites.

Method of application did not effect the K, Ca, Mg, S, Zn, Cu and Fe contents. Except T₁ all other treatments were at par. It is observed that N was higher in the leaves from T₂, T₃ and T₄ than in T₁ which may indicate a positive interaction between N and Mn as stated by Krishnamurthy (1993).

From the above mentioned facts, it is concluded that for obtaining higher N content in leaves ring method of application of N fertilizers has been found to be the best among the methods tried. For obtaining higher leaf Mn content any method other than broadcasting of N fertilizers can be employed. For obtaining higher leaf P content broadcasting of N fertilizer is more suitable. For other nutrients any method of N application can be employed.

6. SUMMARY

Kinnow being a major fruit crop, improving its production and productivity is quite desirable for its commercial cultivation. Though the increase in production and productivity can be brought about by a number of factors, nutrition plays most important factor. Hence, the present investigation entitled “ Variation in leaf nutrient status, yield and quality as affected by varying levels of N, P and K, method and time of application of fertilizers and sampling technique on Kinnow” was taken up to find out the optimum dose of fertilizer and its proper time and method of application. In addition to this, investigations on leaf sampling technique in Kinnow were also taken up to standardise a proper sampling procedure. The salient findings of these investigations are:

1. Amongst different flushes, spring flush (June to October) was found to be superior for sample collection as it produced higher leaf nutrient content. However, only in August all the nutrients analysed were found to be stable.
2. Samples collected from 2nd, 3rd and 4th leaf positions of 4-7 month old terminal shoot on non-fruiting terminals were found to be suitable. For Ca alone, the middle position of the non-fruiting terminal was found suitable.

3. The leaf nutrient content of N, P, Ca, Mg, S, Zn, Cu and Fe were not affected by sample size. However, for K and Mn higher, sample of 70 leaves /tree was found to be superior.
4. Except P and S, all other nutrients in Kinnow leaves were not affected by aspect of the tree. Nevertheless, for P and S samples collected from east and west direction were found to be more suitable in Kinnow.
5. Among different doses of N tried, 600 g/tree/year was found to be superior because it resulted in better yield and quality, besides optimum leaf nutrient contents.
6. 300g/tree/year of P was found to be superior in producing optimum leaf nutrient contents, yield and quality.
7. Medium dose of K 400 g/tree/year application produced optimum leaf nutrient contents, yield and quality in Kinnow.
8. Quarterly application of N with $\frac{1}{2}$ of the dose in February, $\frac{1}{4}^{\text{th}}$ of does in June and remaining $\frac{1}{4}^{\text{th}}$ in October resulted in optimum leaf nutrient content.
9. Among the methods of N application, ring method was found to be superior as it produced optimum leaf nutrients in Kinnow.

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7. CONCLUSION

In conclusion it is recommended that :

- i) For estimating leaf nutrient content in Kinnow grown in North India leaf samples should be taken during August from 2nd to 4th leaf portion of 4-7 month old terminal shoot on non-fruiting terminals. While for estimating N, P, Ca, Mg, S, Zn, Cu and S a minimum sample of 30 leaves is recommended a higher sample size of 70 leaves is recommended for K and Mn.
- ii) Among doses of N, P, K 600 g of N, 300 g of P and 400 g of K/year/tree was found to most suitable for optimum yield quality and leaf nutrient content.
- iii) Application of half of the dose in February and one fourth each in June and October in a ring method as found to be superior.

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